



Future of Pharmacy in Wales: A Delphi Study Exploring the Impact of Digital Technology, Automation and Artificial Intelligence

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Doctorate in Professional Practice

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Preface

Following the completion of my undergraduate pharmacy degree at Nottingham University and subsequent foundation training in northwest England, I have spent the majority of my professional career as a pharmacist in Wales. My career has spanned various sectors, including community pharmacy, the pharmaceutical industry, hospital settings and primary care. Most of my post-registration education has been focused on my roles as both a pharmacist and an NHS manager. In 2009, I commenced a Master's degree in Public Administration at Cardiff Business School. The dissertation component of the course ignited my interest in conducting independent research and advancing to a higher academic level, although my career aspirations and responsibilities as a parent of three children took precedence for several years.

Upon commencing the DProf programme, I had not yet finalised my research topic, though I was certain it would be centred on digital transformation in pharmacy. At that time, I held the position of Head of Transformation and Improvement for Pharmacy at Swansea Bay University Health Board, leading various pharmacy and broader healthcare initiatives across hospital sites and throughout Wales. I had recently obtained funding from the Welsh Government to expand a project which involved implementing Robotic Process Automation (RPA) into medicines invoice management systems across NHS Wales. Our initiative utilised RPA, a form of AI, to create a digital worker (referred to as our Pharmacy bot) designed to undertake repetitive, routine invoice processing tasks. The implementation of the technology enhanced operational efficiency and job satisfaction, whilst reducing the need for additional administrative staff investment. Nevertheless, during the preparatory phases, I devoted considerable time to improving certain staff members' comprehension of the technology and alleviating their fears about utilising it. This highlighted to me the varying levels of digital knowledge within the profession and emphasised the necessity to cultivate digital literacy amongst the workforce. I felt that such a development was crucial to ensure the acceptance and adoption of technological advancements, ultimately benefiting the future of pharmacy.

In the initial taught module of the programme, "Approaches to Research and Academic Communication," I undertook a critical analysis of recent research conducted by Blease *et al.* (2018). Their study employed an online survey to investigate General Practitioners' (GPs) perspectives on the influence of technology and machine learning on their workloads in primary care settings. In my critique, I noted that the paper possessed a clear objective and was both accessible and well-structured. It included a useful summary box of key questions and findings, which effectively highlighted existing knowledge in the field and the study's contributions. The online appendices provided the actual survey, along with valuable insights into the researchers' rationale for survey question design and their selection of response options and scales. Motivated by this paper, I sought similar studies examining pharmacists' perspectives and understanding of the impact of technology and artificial intelligence on their practice. However, my initial search yielded very little original research; I encountered only opinion pieces discussing potential pharmacy applications and possible facilitators and barriers. This lack of published studies inspired the initial concept for my research, linking it to my experience with our RPA Pharmacy bot.

In the course of developing my research proposal, I reviewed several studies that employed the Delphi technique. I elected to adopt this research methodology due to its appropriateness for forecasting and achieving consensus in emerging fields. Additionally, as a novice researcher, I found this an intriguing opportunity to explore a research paradigm distinct from the quantitative approaches commonly utilised in pharmacy and medical studies.

Engaging in this doctoral research has been a rewarding endeavour, despite encountering various challenges. It has admittedly taken longer than initially anticipated, partly due to the necessity of pausing my studies to focus on establishing our local field hospital and setting up a national 'end-of-life' medicines service during the initial phase of the COVID-19 pandemic. Furthermore, taking study leave from work has proven challenging due to staff shortages and operational issues at the hospital sites. Nevertheless, the overall experience has been worthwhile.

Abstract

Digital technology, automation, and artificial intelligence (AI) are poised to significantly transform pharmacy practice. While previous research has explored these innovations in other healthcare professions, there is limited evidence capturing pharmacists' perspectives, particularly within the UK and Welsh contexts. This study addresses this gap by exploring Welsh pharmacists' views on the impact of emerging technologies on pharmacy practice, their priorities for future developments and the perceived enablers and barriers to implementation.

A three-round e-Delphi study was conducted between September 2023 and January 2024 with 38 expert pharmacists across Wales, recruited through purposeful and snowball sampling. Round One involved qualitative data collection from open ended questions, thematically analysed to inform statement development for subsequent rounds. In the quantitative Rounds Two and Three, participants rated and ranked predictive and prioritisation statements. Consensus was defined as >70% agreement, which was achieved on 31 of 39 statements.

Findings reveal optimism regarding the integration of digital technologies in pharmacy. By 2030, participants anticipate widespread use of an electronic medicines record, automated dispensing and AI-assisted functions such as clinical validation, medicines information and pharmacy education. Looking further ahead to 2050, priorities include integration of patient wearables, big data analytics and the single digital health record. Participants expressed confidence in Wales's capacity for innovation, citing national infrastructure, strong professional networks and supportive leadership as key enablers. However, barriers such as fragmented systems, funding constraints and limited digital skills persist.

This research provides timely insights for pharmacy leaders, educators and policymakers seeking to enable digital transformation in healthcare. It highlights the importance of workforce readiness, investment in infrastructure and clear strategic direction. The study contributes original evidence to the literature and offers practical recommendations for shaping digital pharmacy policy and practice in Wales and other similar healthcare systems.

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Chapter 1: Introduction

1.1 BACKGROUND

Across the field of healthcare, the transformative nature of technology has been widely recognised as a means to achieve sustainable healthcare and improve patient outcomes (Topol, 2019). The National Health Service (NHS) Long Term Plan, published in 2019, emphasises the key role of technology in achieving its objectives, empowering clinicians to utilise the full range of their skills, reducing bureaucracy, encouraging research and facilitating service transformation (NHS England, 2019). Digital health focuses on implementing and developing digital technologies to streamline care workflows, improve clinical quality and enable patients to be treated faster, safer and as close to home as possible (Welsh Government, 2021a). To maximise the benefits of technology, it is vital to equip the workforce with the essential “skills, attitudes and behaviours” required to become digitally competent and confident (Topol, 2019, p. 78).

The pharmacy profession has been actively pursuing the redesign of services to make better use of digital technology and innovation, with the aim of improving patient outcomes, enhancing efficiency and addressing some of the workforce challenges (Welsh Pharmaceutical Committee, 2019). However, opinion articles caution that pharmacy jobs may be vulnerable to computerisation, with technological advances and artificial intelligence (AI) potentially threatening future employability (Frey and Osbourne, 2017). Gregorio and Cavaco (2021) anticipate that AI and automation will progressively infiltrate pharmacy practice, replacing tasks such as prescription dispensing, medicine ordering and diagnostics. They recommend that pharmacists adapt and diversify to maintain their relevance as a healthcare profession in the future. Others authors propose that specific tasks currently performed by pharmacists, such as prescription validation, drug interaction identification, outcome monitoring and treatment plan optimisation, could be undertaken by AI in the future. However, changes to current legislation and professional regulation would be required (Dentzer, 2019; Das, Dey and Nayak, 2021). Efforts are required to improve pharmacist’s confidence and trust in digital technology and AI-enabled care and to reassure the pharmacy workforce that implementation will support rather than replace workers,

potentially improving the quality of work rather than threatening it, as recommended by The Health Foundation (2021).

There has been considerable research examining healthcare professionals' understanding and attitudes toward digital health technology and AI, as well as their perspectives on its implications for their future clinical practice (Blease *et al.*, 2018; Blease *et al.*, 2019; Buck *et al.*, 2022; Alanzi *et al.*, 2023; Cobiauchi *et al.*, 2023; Hashmi *et al.*, 2023). However, there are limited studies undertaken within the field of pharmacy, particularly from the United Kingdom (UK) and Europe. The aim of this study is to address this gap in the literature and gather the perspectives of pharmacists on the influence of emerging technologies on pharmacy practice, within the unique context of the Welsh healthcare system.

1.2 STRUCTURE OF THE THESIS

The thesis is structured into six chapters. The first chapter introduces the study and offers an overview of pharmacy practice in the UK, with particular emphasis on the distinctive context of the healthcare system in Wales. It provides the reader with background information on the application of digital technology, automation and AI in pharmacy and healthcare. It outlines the research study's aims and objectives, setting the scene for the subsequent chapters.

Following the introduction, the second chapter describes the literature review strategy and summarises the original studies found that consider pharmacists' attitudes and perspectives on the impact of various emerging technologies on their professional practice and the facilitators and barriers they foresee. This chapter identifies the significant research gap regarding pharmacists' predictions for emerging technologies, particularly within the Welsh and UK context. The third chapter focuses on the research methodology, explaining the rationale behind the chosen approach and detailing the e-Delphi study's project activities.

Chapter four presents a comprehensive analysis of the data collected from the initial qualitative survey and the two subsequent quantitative rounds. The fifth chapter evaluates the research results in relation to the study's objectives and the findings from the literature review, discussing the strengths and limitations of the study and proposing future research

directions. The final chapter concludes the thesis by synthesising the key insights and implications of the research, offering recommendations for the pharmacy profession and broader stakeholders in Wales.

1.3 OVERVIEW OF PHARMACY PRACTICE

The pharmacy profession in Great Britain has a long-standing history, dating back to the 18th century, though its scope and responsibilities have evolved considerably over time (Meyerson, Ryder and Richey-Smith, 2013). Traditionally, pharmacists were primarily engaged in the preparation, supply, and dispensing of medicines, checking prescriptions for safety and potential interactions and providing basic pharmaceutical advice. However, contemporary pharmacy practice has moved towards a more patient-centred model. Pharmacists now utilise their scientific and clinical expertise to play an active role in direct patient care, contributing to therapeutic decision-making and improved clinical outcomes (Atkinson, 2022). The profession has also expanded into advanced therapeutic areas, and from 2026, all pharmacy graduates in Great Britain will qualify as independent prescribers upon registration (RPS, 2022). Pharmacists have extended their scope of practice to encompass advanced therapeutic roles in traditional and emerging areas and from 2026, all pharmacy graduates in Great Britain will qualify as independent prescribers upon registration (RPS, 2022).

The demand for pharmacists continues to grow across healthcare settings, with professionals increasingly recognised as medicines experts, regardless of their specific area of practice (Bochniarz *et al.*, 2022). However, among these, community pharmacists (formerly referred to as high street chemists) remain the most publicly visible and accessible.

1.3.1 Community Pharmacy

Community pharmacists are integral members of the primary care team and are among the most accessible healthcare professionals for patients (Kelling, 2015). Their responsibilities extend beyond medicine supply to include health promotion, public health interventions and an expanding portfolio of clinical services (Tsuyuki *et al.*, 2018). Their accessibility enables them to offer timely advice on minor ailments and medicines without the need for prior

appointments (Hess *et al.*, 2022). Increased utilisation of community pharmacy services has been proposed as a viable solution to alleviate pressures on other parts of the healthcare system (Royal College of Physicians, 2022). In Wales, services such as the Medicines Use Review (MUR) and Discharge Medicines Review (DMR) underscore the role of community pharmacists in enhancing medication safety and continuity of care post-discharge (James *et al.*, 2023). Additional services frequently provided include emergency contraception, smoking cessation, structured medication reviews, vaccination programmes, and long-term condition management (Anderson and Sharma, 2020; Elnaeam *et al.*, 2020; Hess *et al.*, 2022; Eldooma, Maatoug and Yousif, 2023). Despite their value, community pharmacies face ongoing challenges including chronic underfunding, rising operational costs, and increased competition from online providers, all contributing to a notable rise in closures (Paloumpi *et al.*, 2023).

1.3.2 Hospital (Secondary Care) Pharmacy

The role of pharmacists in hospital settings has evolved significantly, with a distinct shift from traditional dispensary functions to advanced clinical roles. While registered pharmacy technicians and support staff continue to perform many of the core dispensing and supply tasks, pharmacists have become increasingly embedded within multidisciplinary teams, delivering direct clinical care (Bochniarz *et al.*, 2022). These clinical pharmacists apply their expertise to ensure the safe and effective use of medicines, working closely with doctors and nurses to resolve medication-related issues and optimise therapeutic outcomes (Bragazzi *et al.*, 2020; Naseralallah *et al.*, 2020; Scott *et al.*, 2023).

Not all hospital pharmacists are patient-facing. Many play critical roles in non-clinical domains, such as medicines production, procurement, policy governance, healthcare management and service redesign. Their contributions also include formulary management, development of clinical guidelines and provision of specialised drug information (Stemer and Williams, 2024). Additionally, hospital pharmacists are actively involved in drug appraisal processes and horizon scanning to prepare the health service for future therapeutic advancements (All Wales Therapeutics and Toxicology Centre, 2024).

1.3.3 Pharmaceutical Industry

Historically, pharmacists in the pharmaceutical industry were primarily involved in compounding and supplying medications. Today, their role spans the entire drug development lifecycle, from early-stage research and formulation development to clinical trials, regulatory affairs, medicines information, quality assurance and commercial strategy (Nguyen, 2020; Bonam *et al.*, 2021). This breadth of involvement highlights the growing impact of pharmacy expertise in bringing safe and effective medicines to market.

1.3.4 Academia

The expansion of pharmacy roles has been mirrored by a growth in pharmacy education. As student numbers have increased, new schools of pharmacy have been established across the UK (Clews, 2023). Within academia, pharmacists are responsible for training undergraduate pharmacy students as well as those from other healthcare disciplines (Patel, Begum and Kayyali, 2016). Furthermore, academic pharmacists are engaged in continuing professional development (CPD) initiatives, ensuring the existing workforce maintains up-to-date skills and knowledge (Sosabowski and Gard, 2008). Many also contribute to research across diverse fields or combine academic responsibilities with clinical practice in the NHS (NHS England, 2024).

1.3.5 Primary Care

In primary care settings, pharmacists are employed by commissioning and provider organisations to monitor prescribing practices and medicines usage. Their work involves evaluating clinical evidence and prescribing data, identifying trends, and developing strategies to promote evidence-based, cost-effective prescribing among general practitioners and other prescribers, thereby improving patient outcomes (Silcock, Raynor and Petty, 2004).

Due to increasing pressures on GPs in primary care and the growing complexity of medication regimens, pharmacists have been integrated into general practice settings (Alshehri *et al.*, 2021). Within these practices, pharmacists undertake a broad range of clinical and non-clinical responsibilities. These include conducting medication reviews, performing medicines reconciliation, managing chronic diseases, developing treatment protocols, promoting cost-

effective prescribing, and helping to reduce polypharmacy (Savickas *et al.*, 2020; Hurley, 2023).

1.3.6 Pharmacy regulation

The regulatory framework governing pharmacy practice in Great Britain is composed of multiple organisations, each addressing distinct facets of the profession. The General Pharmaceutical Council (GPhC) serves as the statutory regulatory authority responsible for the registration of pharmacists, pharmacy technicians and registered pharmacy premises. Its principal purpose is to protect the public by maintaining and enhancing standards of professional conduct, ethics and performance, thereby contributing to the ongoing development and integrity of the pharmacy profession (GPhC, 2024). Complementing this regulatory function, the Royal Pharmaceutical Society (RPS), established in 1841, acts as the professional leadership body for pharmacists in England, Scotland and Wales. The RPS is dedicated to setting and promoting professional standards, advancing the practice of pharmacy and advocating for the role of pharmacists within the healthcare system, ultimately aiming to improve patient care and public health outcomes (RPS, 2022).

1.3.7 Summary

Pharmacy practice in Great Britain has evolved into a patient-centred profession spanning community, hospital, industry, academia and primary care. Pharmacists contribute to clinical care, medicines optimisation, education, research, and policy, supported by robust regulation from the GPhC and professional leadership from the RPS. While the sector continues to face financial pressures, demographic changes, and a shift towards community care, emerging technologies and personalised medicine offer opportunities for continued innovation and professional growth (RPS, 2022).

1.4 DIGITAL TECHNOLOGY, AUTOMATION AND ARTIFICIAL INTELLIGENCE IN HEALTHCARE AND PHARMACY

The World Health Organization (WHO) defines health technology as the “application of organised knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of lives” (2007, p. 1). The

NHS recognises technology as pivotal to support the workforce support and future healthcare demands, with the Topol Review emphasising the need for a digitally literate workforce (Topol, 2019).

Automation in healthcare involves using technology to perform repetitive tasks traditionally done manually, enhancing efficiency and accuracy (Alzahrani, Aledresee and Alzahrani, 2023; Asan, Bayrak and Choudhury, 2020; Kaye and Pate, 2022; O'Kane *et al.*, 2021). Applications range from laboratory automation to pharmacy dispensing robots to robotic surgeries (Bhattacharya, 2016), alleviating workforce pressures by allowing healthcare professionals to focus on high-value activities (Hardie *et al.*, 2021). Digital health encompasses various technologies, including electronic health records, wearable technologies, AI, big data analysis and genomics. AI is a computer program that makes intelligent decisions using mathematical models based on data (Asan, Bayrak and Choudhury, 2020). Machine learning (ML), a subset of AI, focuses on algorithms that allow machines to improve performance through data-driven learning (Stafie *et al.*, 2023). In healthcare, AI and ML applications are increasingly used for patient diagnosis, symptom management and treatment recommendations through clinical decision support tools (Lai *et al.*, 2020; Bajgain *et al.*, 2023).

Digital transformation integrates these technologies to improve healthcare delivery and patient engagement (Stoumpos, Kitsios and Talias, 2023). However, challenges such as digital illiteracy, infrastructure limitations and financial constraints hinder progress (Iyanna *et al.*, 2022; Borges do Nascimento *et al.*, 2023). The COVID-19 pandemic accelerated digital adoption, particularly in virtual consultations and telemedicine, fostering increased public trust in digital platforms (Hutchings, Scobie and Edwards, 2021; le Roux-Kemp, 2023). Studies suggest that healthcare workers are willing to adopt technology when adequately supported (Horton *et al.*, 2021; Johns *et al.*, 2023).

Despite recent advancements, the effective integration of technology and AI into healthcare settings continues to face significant challenges. It is crucial to foster trust in these technologies and to enhance the workforce's understanding of their capabilities and limitations. Additionally, it is important to establish more efficient and reliable interactions between humans and technology. Research underscores the necessity of involving end-users

in the design, development, implementation, and evaluation of health technologies within their work environments (Kushniruk and Borycki, 2021; Salwei *et al.*, 2021). Furthermore, there is a pressing need to strengthen governance and assurance processes to ensure accountability, transparency and the mitigation of algorithm bias (Horton *et al.*, 2021; Jermutus *et al.*, 2022).

Pharmacy has seen significant advancements in technology and applications across diverse various healthcare systems and sectors. These innovations aim to improve patient care, enhance medication safety and optimise pharmacy operations. The next section will highlight various examples of technological implementation in pharmacy, as well as more recent smaller-scale trials.

1.4.1 Pharmacy Automation

Automation in pharmacy improves efficiency, reduces errors and enhances storage capacity (Fitzpatrick *et al.*, 2005; Kuiper *et al.*, 2007; Al Nemari *et al.*, 2019; Batson *et al.*, 2020). Studies highlight improved space utilisation, staff efficiency and a reduction in dispensing errors (Rodriguez-Franklin *et al.*, 2008; Gonzalez *et al.*, 2018), though proposed financial benefits can take years to materialise (Berdot *et al.*, 2008). Smaller automated dispensing units, such as point-of-care dispensing cabinets in wards, out-patient clinics and emergency departments in hospitals, are used to facilitate remote medication management in hospitals, particularly for controlled drugs. Studies show their introduction can improve medicines security and the efficiency of supply (Gordon *et al.*, 2005; McCarthy and Ferker, 2016; O'Kane *et al.*, 2021; Kaye and Pate, 2022; Alzahrani, Aledresee and Alzahrani, 2023).

Some larger community pharmacies and online pharmacy warehouses are implementing dispensing automation, with some multiples using large-scale centralised automated dispensing to support "hub and spoke" models to improve efficiency across large regions (Moreton, 2017; Fong, 2018; Gregorio and Cavaco, 2021). However, smaller and independent pharmacies face financial and operational challenges to automation, with concerns raised over policy shifts and related remuneration (Anekwe, 2018; Community Pharmacy Wales, 2020).

Within Wales, automated dispensing was adopted across all acute NHS hospitals following recommendations from the Audit Commission and the subsequent Welsh Government pharmacy redesign funding (Audit Commission, 2001; James *et al.*, 2011). Relating to this national implementation project, a small-scale longitudinal case study was undertaken in a Welsh hospital revealing post-automation there is a significant increase in dispensary throughput by 43% and a reduction in the rate of prevented dispensing incidents by 56% within the hospital (James *et al.*, 2013a). James *et al.* (2013b) also conducted a qualitative study in the same hospital to assess pharmacy staff's perspectives on the impact of automation. This study is one of the only in the UK that examines the perceptions of pharmacists regarding this technology, rather than just technical or efficiency-based evaluations. The findings of this research are explored in greater depth in the subsequent literature review chapter, providing a more comprehensive understanding of the socio-technical aspects of implementing new technologies in healthcare settings.

1.4.2 Electronic Prescribing

Electronic prescribing (or e-prescribing) is defined as “the utilisation of electronic systems to facilitate and enhance the communication of a prescription or medicine order, aiding the choice, administration and supply of a medicine through knowledge and decision support, and providing a robust audit trail for the entire medicines use process” (NHS Connecting for Health, 2009, p. 9). The digitisation of prescribing reduces transcription errors and enhances medication safety through the reduction of preventable adverse drug events (Nuckols *et al.*, 2014). Studies highlight benefits such as improved workflow efficiency, remote access for prescribers and compliance with hospital formularies, as well as challenges including hardware issues, required training and potential reduced patient interaction (Nanji *et al.*, 2014; Micallef *et al.*, 2017; Connor *et al.*, 2020).

The integration of electronic prescribing systems in England has been supported by NHS funding (Perera, Heeney and Sheikh, 2022). However, due to the devolution of health responsibilities, the implementation of these systems varies across the UK. At the time of this study, only one health board in Wales has adopted electronic prescribing (Digital Health and Care Wales, 2024a). Notably, the perspectives of pharmacists in Wales regarding this technology and its implications for their current and future practice, have not been examined.

1.4.3 Electronic Health Records

Electronic Health Records (EHRs) are digital representations of patients' healthcare information, encompassing a comprehensive range of data such as medical histories, diagnoses, laboratory results, immunisation records, medication and allergies recorded over the course of their lives (Seymour, Frantsvog and Graeber, 2012). EHRs have been shown to enhance the quality of care by improving clinical documentation, promoting patient safety and increasing the efficiency of healthcare delivery (Alex *et al.*, 2016). Research indicates that EHRs support medication reconciliation and chronic disease management, reduce hospital readmissions, facilitate communication among healthcare providers and inform clinical decision-making (Gloth, 2010; Enahoro *et al.*, 2024). Nevertheless, the implementation of EHR systems presents several challenges, including high financial costs, concerns regarding data security and issues related to interoperability (Seymour, Frantsvog and Graeber, 2012). Furthermore, while EHRs contribute to a reduction in certain medication errors, they do not eliminate them entirely, highlighting the need for ongoing system improvements and increased pharmacist involvement in medication reviews (Alex *et al.*, 2016; Classen *et al.*, 2020).

1.4.4 Telehealth and Telemedicine

Telehealth or telemedicine encompasses healthcare services that are conducted remotely, without regard to the physical locations of either the patient or the healthcare professional (Alghamdi *et al.*, 2022). Telemedicine gained significant importance in healthcare delivery during the COVID-19 pandemic (le Roux-Kemp, 2023). Successful implementations in NHS Wales include videoconferencing for outpatient consultations and emergency telemedicine services for paediatric cardiac emergencies (Johns *et al.*, 2021; Uzun *et al.*, 2022). Case studies in the field of pharmacy have demonstrated that telemedicine services are effective in addressing drug-related issues, enhancing prescription safety and delivering clinical pharmacy services to patients in rural areas (Senbekov *et al.*, 2020; Melton *et al.*, 2021; Amundson *et al.*, 2022). However, the perspectives of pharmacists regarding the future utilisation and expansion of telemedicine applications to improve pharmaceutical care have not been documented.

1.4.5 Patient Wearables

Patient wearables have evolved from simple fitness trackers to sophisticated devices monitoring various vital signs and personal metrics (Guo *et al.*, 2021). These technologies have shown potential in improving medication adherence, particularly for chronic conditions like hypertension, diabetes and dyslipidaemia (Juusola *et al.*, 2019; Quisel *et al.*, 2019). Wearables can provide medication reminders, integrate behavioural science techniques for compliance and allow continuous monitoring of physiological parameters (Armitage, Kassavou and Sutton, 2023; Chalasani *et al.*, 2023). The integration of wearables with healthcare systems will enable real-time data transmission to healthcare professionals, facilitating informed decision-making, early intervention and safer hospital discharge (Devi *et al.*, 2023). In the future the increased ability to connect and integrate wearables with other health data and medical records through “cyber-physical systems” will enhance the accuracy and timeliness of patient data (Lin *et al.*, 2024, p. 141).

While the potential benefits of wearable technology in healthcare are evident, current research is limited to small-scale studies with a lack of long-term outcome data (Watt, Swainston and Wilson 2019; Volpato *et al.*, 2021). Pharmacists are well-positioned to harness wearable data for optimising medication regimes and providing personalised lifestyle advice. However, there is a notable absence of studies specifically examining pharmacists' use and perceptions of wearable technology data.

1.4.6 Pharmacy Education

The COVID-19 pandemic accelerated the adoption of digital technologies in education, leading to widespread transition to online remote learning. While this allowed education to continue during health protection measures, the long-term consequences for student learning and skill development remain unclear (Lyons, Christopoulos, and Brock, 2020; Research has identified challenges such as poor internet connectivity, limited digital literacy and insufficient technical support (Qureshi, Khawaja and Zia, 2020). Post-pandemic, a hybrid teaching environment has emerged, blending face-to-face learning with remote technology. While this approach leverages the benefits of both methods, it requires careful planning and

facilitation and raises concerns about equitable access to technology and potential educational disparities (Silva *et al.*, 2022).

In pharmacy education, digital technology and AI show significant potential for enhancing student engagement. Innovative approaches include augmented reality tools, AI integration in medicinal chemistry modules and AI chatbots for simulating clinical interactions (Hope *et al.*, 2022; Roosan *et al.*, 2022; Culp *et al.*, 2024). However, these methods require thorough evaluation against conventional teaching approaches to determine their long-term impact on student learning and professional competency (Amalanathan, 2024).

The evolving professional landscape influenced by digital technology and AI necessitates adaptation of pharmacy education curricula. Recommendations include developing students' critical evaluation skills for AI-enhanced work and enhancing digital literacy among pharmacy undergraduates (Cain, Malcom and Aungst, 2023; Allowais *et al.*, 2024). Despite the proposed benefits, universal integration of AI technologies in pharmacy education remains limited, with challenges including insufficient planning time, scarcity of expertise, ethical concerns and practical matters such as technical compatibility and information security cited (Fernández-Alemán *et al.*, 2016; Nakagawa *et al.*, 2022; Silva *et al.*, 2022; Abbas *et al.*, 2023; Abdel Aziz *et al.*, 2024).

1.4.7 Artificial Intelligence

AI-enabled clinical decision support systems (CDSS) are designed to assist healthcare professionals in making informed decisions about patient treatments and medications (Park *et al.*, 2019). They do so by providing access to vast amounts of complex information in a targeted and structured way (Chalasani *et al.*, 2023). These systems can enhance interoperability between various health information systems, including patient databases, clinical knowledge summaries and the latest research evidence, and provide support frameworks for tasks such as handling incomplete patient data and optimising healthcare datasets (Haldorai and Ramu, 2021). By matching individual patient characteristics and test results to a computerised clinical knowledge base, CDSS can present patient-specific assessments or recommendations to clinicians, thereby augmenting their own professional decision-making process (Sutton *et al.*, 2020).

Emerging evidence underscores the potential advantages of CDSS in enhancing future clinical decision-making. As artificial intelligence (AI) technologies, particularly those based on machine learning (ML), continue to advance by assimilating insights from increasingly comprehensive and complex datasets, the precision and personalisation of their clinical recommendations are expected to improve (Bajgain *et al.*, 2023; Lui *et al.*, 2023). They are able to reinforce the strengths of current medical practice by analysing large complex datasets without experiencing cognitive fatigue. When embedded within clinical systems, these tools facilitate continuous, 24-hour patient monitoring and can autonomously trigger alerts to prompt timely clinical interventions when necessary (Hah and Shevit Goldin, 2021).

Although a significant number of CDSS tools remain in various stages of development, evaluation or validation, certain medical specialities have demonstrated early and proactive adoption. For instance, ophthalmology has emerged as a leader in integrating AI-driven CDSS, employing patient-specific data to assess changes in clinical parameters, monitor disease manifestations and evaluate therapeutic outcomes in the management of glaucoma (Bekbolatova *et al.*, 2024). Likewise, the integration of AI technologies within radiology has become increasingly widespread, offering enhanced diagnostic imaging capabilities to assist radiologists in the detection and interpretation of oncological and pathological findings that may otherwise elude human observation (Okolo *et al.*, 2021; Rainey *et al.*, 2021; Philip *et al.*, 2022). Furthermore, Salwei and Carayon (2022) advocate for the adoption of a sociotechnical systems (STS) approach in the design and implementation of CDSS, particularly in the context of pulmonary embolism diagnosis within Emergency Departments, emphasising the critical importance of aligning technological innovations with the broader clinical work system to optimise workflow integration and clinical efficacy.

Within pharmacy practice and broader medicines management, the potential applications of CDSS are extensive. These technologies can facilitate data analysis and assist in therapeutic decision-making, particularly for patients with multiple comorbidities and complex treatment regimens. CDSS can also intervene to prevent medication errors, minimise the risk of drug interactions and avoidable adverse events, reduce pharmaceutical expenditures and support appropriate therapy and dose selection (Tolley *et al.*, 2018; Liefwaard *et al.*, 2021; Raza *et al.*,

2022; Chalasani *et al.*, 2023; Ranchon *et al.*, 2023). Furthermore, CDSS represent a valuable resource for pharmacy teams, promoting adherence to prescribing guidelines and clinical protocols (Sutton *et al.*, 2020). Despite these advantages, the literature identifies significant concerns regarding AI-enabled CDSS, notably issues related to the clinical accuracy and validation of AI algorithms, data privacy and security challenges and a general lack of understanding and trust among clinicians and end-users, which collectively impede the broader acceptance and integration of AI technologies into clinical practice (Wang *et al.*, 2022; Sivaraman *et al.*, 2023).

AI-powered chatbots and generative AI technologies present opportunities in patient communication, medication adherence monitoring and broader healthcare automation (Altamimi *et al.*, 2023; Görtz *et al.*, 2023). However, current evidence supporting their effectiveness within pharmacy settings remains limited. Moreover, existing AI models lack the sophisticated reasoning capabilities necessary to manage complex clinical scenarios, raising concerns regarding their accuracy, safety and reliability. Accordingly, the literature emphasises the need for rigorous validation processes and cautious integration into healthcare environments to safeguard patient safety and maintain clinical effectiveness (Huang *et al.*, 2023; Lui *et al.*, 2023; Bekbolatova *et al.*, 2024).

In the context of electronic health records (EHRs), AI analytics, particularly those employing machine learning and natural language processing, can interpret unstructured data and enhance predictive modelling for patient health management (Del Rio-Bermudez *et al.*, 2020; Chalasani *et al.*, 2023). AI technologies also offer significant potential in the areas of post-marketing surveillance and pharmacovigilance (Slee, Farrar and Hughes, 2002; Chalasani *et al.*, 2023). Nonetheless, realising the full benefits of AI in healthcare will require addressing persistent challenges related to data accuracy, algorithmic bias, privacy, and the standardisation of EHR formats (Nashwan and Hani, 2023). Additionally, concerns regarding sampling bias have been noted, as EHR data are typically collected during healthcare encounters, which may disproportionately represent individuals with more severe health conditions (Maddox, Rumsfeld, and Payne, 2019).

The pharmaceutical industry is increasingly incorporating AI and ML technologies into various stages of drug development, from discovery to post-marketing surveillance. These technologies significantly accelerate drug discovery and development processes, enabling more precise and efficient methods in drug research (Slee, Farrar and Hughes, 2001). AI is used to identify biomarkers, design new compounds, and reduce development time by selecting compounds with favourable pharmacokinetics, efficacy and reduced toxicity (Kim *et al.*, 2020). Furthermore, AI is employed to screen and repurpose existing medicines for new therapeutic indications, potentially reducing research and development time, costs and risks (Khan *et al.*, 2023). AI has the potential to enhance clinical trials by improving trial design and patient recruitment, however challenges such as algorithmic biases, data quality issues and regulatory compliance concerns have been identified (Koromina, Pandi and Patrinos, 2019; Gupta, 2022; Yadav *et al.*, 2024). It is anticipated that digital automation technologies will play an increasingly critical role in future pharmaceutical production, streamlining development processes and enabling the manufacture of personalised medicines (Hariry, Barenji and Paradkar, 2020; Reinhardt, Oliveria and Ring, 2020; Milenkovich, 2023).

The application of AI in pharmacogenomics is advancing rapidly, enabling the analysis of complex genetic data to identify variations that influence drug metabolism and effectiveness (Abdelhalim *et al.*, 2022; Atkinson, 2022; Lee and Swen, 2023; Sadee *et al.*, 2023). Pharmacists are expected to play a leading role in the interpretation of pharmacogenomic test results and their translation into clinical practice. However, additional training in this field is essential to ensure the profession can effectively leverage these emerging technological capabilities (Haga, 2023; Balogun *et al.*, 2024).

1.4.8 Summary

Understanding the current applications and limitations of digital technology, automation and AI in and pharmacy is crucial for contextualising this study. It highlights the emerging opportunities and challenges that pharmacists must navigate, providing the foundation for this research exploring Welsh pharmacists' expectations and priorities for future technological integration.

1.5 BARRIERS TO THE USE OF DIGITAL TECHNOLOGY AND AI IN HEALTHCARE AND PHARMACY

Although the potential for digitalisation and AI to transform healthcare has been demonstrated in various studies. However, practical, technological and cultural obstacles have been identified that are delaying more extensive acceptance and implementation. A meta-analysis of systematic reviews on barriers and facilitators for the use of digital health technologies by healthcare professionals reveals that infrastructure and technical challenges are the most commonly reported hindrances. These challenges include issues such as insufficient network coverage and connectivity; inadequate technology, devices, databases and storage; lack of compatibility with daily workflow; and absence of standardised systems, integration and interconnectedness (Borges do Nascimento *et al.*, 2023).

1.5.1 Lack of Infrastructure

One of the most significant challenges to incorporating digital technology and AI into healthcare systems is the lack of digital infrastructure and interoperability. In the UK, a complex network of hierarchical structures exists that contains patient health data across various healthcare settings and systems which may not be able to communicate or exchange information accurately (Heed *et al.*, 2021; Tolley *et al.*, 2023). Machine learning (ML) technologies require access to large data sets, powerful computing resources and sophisticated algorithms to be successful. However, most healthcare data are not readily available for ML and are stored in different formats and distinct organisational silos with poor system interoperability (Kelly *et al.*, 2019; Lee and Yoon, 2021). For instance, the persistent use of paper patient records and medication charts in the UK serves as a significant barrier to allowing AI access to complete and valuable patient data (Fennelly *et al.*, 2020).

1.5.2 Funding Constraints

In order to improve digital infrastructure and data accessibility, substantial financial investment is necessary at both organisational and national levels. Investment is required for the initial procurement of the AI system, licenses, hardware, as well as making any necessary modifications to the infrastructure. This includes upgrading servers, enhancing network capabilities and modifying physical spaces. There are ongoing costs associated with constantly updating the system and maintaining robust cybersecurity measures

(Esmaeilzadeh, 2024). There is also the investment in staffing resource in terms of workforce time required for implementation, training and workflow transition management support (Borges do Nascimento *et al.*, 2023; Esmaeilzadeh, 2024). Research conducted by Alsobhi *et al.* (2022) reveals that cost is the primary barrier to AI implementation in rehabilitation practices among physical therapists surveyed in Saudi. The participants expressed concerns about the initial purchase of equipment and ongoing training and implementation costs.

Tolley *et al.*'s (2023) study of NHS clinicians and managers presents a more nuanced view, suggesting potential financial benefits from digital technology implementation. The contrast between high initial costs of EHR and CDSS and overall positive financial impact requires further investigation to understand the timeframe and conditions under which these benefits materialise. Alternative models have demonstrated the ability to lower initial investment expenses through shared risk and multisector reimbursement schemes. Research by Borges do Nascimento *et al.* (2023) suggests that encouraging the development and implementation of AI technologies to enhance patient outcomes and decrease costs can promote their adoption within the healthcare sector. However, more rigorous economic analyses are needed to validate these approaches and quantify their potential impact on healthcare organisations' financial performance.

1.5.3 Legal and Ethical Concerns

The integration of AI in healthcare raises significant concerns regarding accountability when AI-based recommendations lead to patient harm (Altamimi *et al.*, 2023). In their recent evaluation of AI in healthcare, Rahman *et al.* (2024) cite the 2019 Hannun *et al.* study, which showed that AI outperformed the average cardiologist in diagnosing arrhythmias. They present a conundrum: 'While a cardiologist may make the best decision by relying on AI when uncertain, who bears responsibility if the AI misdiagnoses?' They point out that legal action would be exceptionally challenging as AI cannot be held accountable. Bekbolatova *et al.* (2024) share this perspective, emphasising the ambiguity surrounding liability when AI decisions lead to harmful medical errors. They question whether the healthcare provider, AI system developer, or the machine itself should be legally responsible. Chalasani *et al.* (2023) question how the current model of accountability for poor decisions resulting in negative

outcomes could remain. They argue that it may be unfair to hold medical practitioners responsible if they were not involved in creating the AI algorithm, whilst attributing accountability to developers is too far removed from the clinical setting. Although these perspectives on AI accountability in healthcare are interesting, they do little to alleviate the apprehensions of healthcare professionals regarding the implementation of AI systems.

Jones, Thornton and Wyatt (2023) report that clinicians have considerable concerns regarding AI and CDSSs, particularly regarding potential legal implications such as liability issues. These uncertainties may impede the development of trust and confidence in AI technologies, potentially hindering their acceptance and implementation in clinical practice.

The development of effective regulatory measures for safe and responsible AI usage presents a significant challenge to policymakers, exacerbated by the rapid pace of technological innovation (Kelly *et al.*, 2019). Lee and Yoon (2021) emphasise the importance of high-quality data, advocating for healthcare organisations to prioritise data quality improvement efforts to enhance validity, reduce risk and increase confidence in AI outputs. They also propose the establishment of a legal framework for information sharing to facilitate real-time access to data for AI applications. However, this recommendation raises ethical concerns regarding patient privacy and data security, as highlighted by Rahman *et al.* (2024).

Bekbolatova *et al.* (2024) emphasise the necessity for AI systems to be transparent and explainable to promote comprehension and adoption among health professionals. This highlights the need to enhance AI education for healthcare workers. Additionally, the study identifies obtaining clear and informed consent from patients as a crucial ethical and legal consideration when acquiring and utilising datasets for AI training. Al Kuwaiti *et al.* (2023) raise a pertinent ethical concern regarding the potential for AI systems to inadvertently reinforce and amplify existing biases in healthcare data. This could lead to disparate treatment or incorrect diagnoses for patients from underrepresented groups, further exacerbating health inequities.

1.5.4 Resistance from Healthcare Professionals

The aforementioned challenges can result in resistance from healthcare professionals, preventing the integration and adoption of technology and AI into their working practices. In order to improve the trust and acceptance of new technology, Jermutus *et al.* (2022) emphasise the importance of involving end-users in the development process. Health professionals need to possess a comprehensive understanding of AI's principles, its capabilities and limitations, and have an increased AI literacy through education. Research conducted by Horton *et al.* (2021) and Tolley *et al.* (2023) highlights that workforce confidence in automation and AI is vital for the NHS to obtain the maximum benefits from emerging technologies. These studies make recommendations to improve the confidence of the workforce, which include strengthening legal and regulatory governance to provide assurance to the workforce and address issues such as accountability, transparency and algorithmic bias.

The research conducted by Jussupow, Spohrer, and Heinz (2022) emphasises the importance of AI implementation projects being aware of the potential threats that may be perceived by the workforce, to both professional and personal identity. In their investigation of medical students and physicians in Germany, they discover that concerns over the erosion of professional recognition and capabilities lead to feelings of self-threat and subsequent identity protection responses, which in turn result in resistance to the integration of technology and AI in healthcare settings.

1.5.5 Summary

To summarise, whilst digital technology and AI offer considerable promise in healthcare, their widespread adoption faces numerous barriers. These challenges include insufficient digital infrastructure, interoperability issues and financial constraints that hinder the acquisition and maintenance of systems. The integration of AI in clinical environments is further complicated by legal and ethical issues related to accountability, liability and patient confidentiality. Furthermore, the resistance from healthcare professionals, stemming from a lack of understanding, trust and concerns about professional identity, presents a substantial challenge. To overcome these barriers, a multifaceted approach is required involving

investment in digital infrastructure, establishment of clear regulatory guidelines, AI education for healthcare workers and strategies to address the concerns of health professionals.

Identifying these barriers is essential to framing the context in which pharmacists will operate as digital transformation advances. By recognising infrastructure, legal, ethical and workforce challenges, this study is better positioned to explore pharmacists' perceptions of obstacles that may impede the adoption of technology within pharmacy practice in Wales.

1.6 ENABLERS TO THE USE OF DIGITAL TECHNOLOGY AND AI IN HEALTHCARE AND PHARMACY

The development of healthcare technology has been greatly accelerated by advancements in methods and techniques, as well as increases in computing power (Busnatu *et al.*, 2022). AI algorithms depend on extensive datasets to learn from, but the quality of the data is crucial for improving the accuracy of their outputs (Lee and Yoon, 2021). Although technology and data are the primary enablers of progress, the literature suggests that there are several other strategies that can facilitate implementation and increase the likelihood of achieving desirable outcomes (Borges do Nascimento *et al.*, 2023; Bekbolatova *et al.*, 2024).

1.6.1 Supportive Regulatory Framework

To enable the rapid advancements in the field of digital technologies and AI in healthcare, a comprehensive regulatory framework is essential to address issues such as transparency, data accuracy, quality control, bias mitigation, liability, privacy and security (Zhang and Zhang, 2023). A regulatory framework ensures the safe, ethical and effective implementation of digital technology, thereby instilling confidence in healthcare professionals and the general public (Esmaeilzadeh, 2024). In a meta-analysis conducted by Borges do Nascimento *et al.* (2023), recommendations are made to establish an international legal framework and legislative norm that would define healthcare professionals' liabilities and clarify security regulation policies, which could help to ensure patients' privacy and confidentiality.

To promote the adoption of AI in healthcare whilst addressing ethical concerns, Rahman *et al.* (2024) suggest several measures. They emphasise the importance of obtaining full consent from individuals for the use of their health data. Furthermore, they advocate for client-side

data encryption to safeguard privacy. The researchers also propose utilising federated learning techniques, which allow AI systems to gain experience in processing healthcare information without the need for direct data sharing. In the UK, the aforementioned AIDRS is developing a large training dataset of healthcare data to allow for training and evaluating AI tools before allowing integration into healthcare systems (NHS AI Lab, 2024).

The importance of establishing a legal framework for information access and sharing in the context of AI applications to enhance trust in these emerging technologies is highlighted by Lee and Yoon (2021). Borges do Nascimento *et al.* (2023) suggest that a critical factor in instilling confidence among patients and healthcare professionals when sharing medical information is the strength of cybersecurity measures. Bekbolatova *et al.* (2024) emphasise the necessity of robust data protection systems to safeguard sensitive patient data from cyber-attacks and operational errors in vulnerable electronic platforms.

1.6.2 Patient and Public Engagement

According to Bekbolatova *et al.* (2024), the need to improve public opinion and enhance patient engagement with digital transformation is crucial for positive progress in this area. Like healthcare professionals, patients and the general public must be educated to boost trust and acceptance of AI technologies. Research conducted by Lee and Yoon (2021) reveals that patients are more likely to participate in an AI-supported treatment processes if they are informed through popular media or their clinician about the potential advantages including faster and more accurate diagnoses, reduced medication errors and lower medical costs.

However, Armando *et al.* (2023) observe in their analysis of CDSS research, that many studies overlook activities aimed at improving patient engagement and do not provide a summary report for patients or follow-ups with patients after the intervention. The researchers identify this as a limitation and suggest that future studies and evaluations should include patient involvement as a measurable outcome.

1.6.3 Collaboration with Healthcare Professionals

The value of collaboration and partnerships among various stakeholders in accelerating the development and implementation of AI in healthcare has been documented in the literature. According to systematic reviews examined by Borges do Nascimento *et al.* (2023), user engagement with system developers and other specialists is crucial at all stages of the design, development and deployment of digital applications to guarantee their usability and ensure they are based on the requirements and expectations of healthcare providers. They also report that the participation of healthcare professionals in the evaluation and validation of AI algorithms within real-life clinical environments is essential to demonstrate their safety and efficacy, and to foster trust. Lee and Yoon (2021) support this finding, stating that the extent to which AI companies collaborate with real-world healthcare experts during the development, implementation and analysis phases of an application can influence the success or failure of the medical AI tool.

The education of healthcare professionals plays a crucial role in facilitating the adoption of new technologies. According to Kelly *et al.* (2019), it is essential for clinicians to understand how algorithms can enhance patient care within their specific practice. They emphasise the need to develop knowledge and critical evaluation skills early in one's career or at the undergraduate level through the curriculum. Esmaeilzadeh (2024) highlights the significance of fostering AI literacy among future healthcare professionals, while Lee and Yoon (2021) suggest that AI education should be incorporated into most university programmes, including medical degrees. In the field of pharmacy education, scholars emphasise the importance of early exposure to AI to ensure its effective integration into future pharmacy practice (Cain, Malcom and Aungst, 2023; Abdel Aziz *et al.*, 2024; Allowais *et al.*, 2024).

1.6.4 Assurance of Professionals

Through increased education and awareness of the capabilities and limitations of technology and AI, professionals will gain assurance that their roles will not become obsolete. Chalasani *et al.* (2023) describe the fear of replacement leads to distrust and resistance to AI-based interventions. Esmaeilzadeh (2024) emphasises that organisations need to change the perception of AI as a potential threat to staff to that of an enabling partner, with the ability

to augment clinical expertise, improve patient care and create new more-rewarding healthcare roles rather than simply replacing jobs.

Tolley *et al.* (2023) describe the importance of approaching digital transformations carefully and being mindful of the working environment, including any potential stressors such as multiple IT systems and projects present. They state it is essential to communicate and actively monitor the goal of improving professionals' working environment, along with sharing examples of good practices and initiatives. According to Lee and Yoon (2021), professionals should be educated on the numerous advantages of employing technology to undertake repetitive tasks or complex data analysis. By delegating these responsibilities to technology, professionals can release capacity and redirect their time to spend more time with their patients allowing for unique human connections founded on empathy and trust.

A review of studies incorporating AI and ML based CDSS in mental health settings in Australia and New Zealand, finds that most significant barriers to implementation arise from issues with clinicians' reluctance to trust in the clinical capabilities of the technology and accept the CDSS recommendations (Higgins *et al.*, 2023). The researchers recommend that engaging clinicians in the development and implementation of new health technologies should improve system transparency, increase clinician confidence and ensure end-user acceptance of these digital tools.

1.6.5 Professional Leadership

Research emphasises the crucial role of strong leadership in healthcare for inspiring others to provide high-quality patient care, enhancing healthcare delivery efficiency and aligning organisational objectives with patient needs (Greening, 2019; Reed, Klutts and Mattingly, 2019). Leaders play a vital role in the success of a digital project by not only providing the necessary funding, talent and resources but also fostering a culture of organisation-wide innovation and collaboration (NHS Leadership Academy, 2013; Chen and Decary, 2020). A study of Irish hospitals by Hogan-Murphy *et al.* (2021) revealed that clinical leaders and champions were pivotal in facilitating the successful implementation of digital medicines systems.

The pharmacy sector has acknowledged the significance of leadership, with the RPS identifying leadership skill development as a key component of the advanced practice framework for pharmacists (RPS, 2013; Reed, Klutts and Mattingly, 2019). Tigre, Curado and Henriques (2023) highlight the need to cultivate specific digital leadership characteristics to excel in the emerging digital landscape, including communication, goalsetting, openness, trust, adaptability, teamwork, creativity, empowerment and flexibility. In order to enable pharmacists to lead digital innovation and harness the benefits of technology in healthcare, it is imperative that professional bodies, educational institution and employers encourage the evolution and adaptation of leadership skills to address the challenges presented by the digital environment.

1.6.6 Clinical Informaticians and Digital Clinical Leads

Digital clinical leads and clinical informaticians comprise a multidisciplinary group from various disciplines including medicine, nursing, pharmacy and other biological sciences. They fulfil a diverse yet crucial role in bridging the gap between health informatics, digital technology and healthcare practice, ensuring that data and digital innovations are effectively utilised in clinical settings to maximise benefits for both healthcare providers and patients (Davies, Mueller and Moulton, 2020).

Within pharmacy, various titles are employed for these roles including informatics pharmacists, pharmacy informaticians or more generalised clinical informaticians. However, these roles can be broadly defined as pharmacists who specialise in the development, implementation, and utilisation of digital health systems, health-related digital tools and data analysis to enhance patient outcomes (Ismail *et al.*, 2023).

The clinical informatics pharmacist is an emerging role in the UK, although international research from other healthcare systems has reported on the benefits. These advantages include facilitating communication and collaboration between clinical and digital teams and extracting meaningful insights from vast amounts of medicines-related data to improve patient care (Bakker *et al.*, 2024). An Australian study demonstrates the value of informatics

pharmacists during the COVID-19 pandemic, including enabling the rollout of digital health systems, improving the provision of medication supply optimisation and undertaking data analysis to ensure timely and accurate clinical decision-making (Falconer, Monaghan and Snoswell, 2021). Bakker *et al.* (2024) recommends promoting advanced training in pharmacy informatics (as opposed to the current practice of 'learning on the job') to ensure the full benefits are realised from these roles in terms of patients and healthcare system outcomes.

1.6.7 Summary

Successfully embedding digital technologies into pharmacy practice requires a coordinated whole-systems approach to change management, incorporating strategic, structural, and cultural dimensions. Key structural enablers include robust digital infrastructure, sustainable funding mechanisms and supportive regulatory frameworks that promote innovation and interoperability across care settings. Strategic change can be facilitated by alignment with national policies, for example 'Pharmacy: Delivering a Healthier Wales' (Welsh Pharmaceutical Committee, 2019), to ensure digital initiatives reinforce broader pharmacy and healthcare priorities.

Equally critical is cultural transformation, which involves engaging both patients and healthcare professionals to foster trust, acceptance and meaningful co-design of automation and AI tools. Involving end users throughout the development and implementation phases helps ensure that technologies are clinically relevant, ethically sound and aligned with real-world needs. Educating healthcare professionals on the role of AI as a tool to augment, rather than replace, clinical judgment is essential for overcoming resistance and encouraging adoption. Strong professional leadership is necessary to drive innovation and create a culture that embraces digital transformation. Emerging roles such as clinical informaticians and digital clinical leads are critical in bridging the gap between technological innovation and pharmacy practice, enabling the safe and effective integration of digital tools to enhance patient outcomes and system efficiency.

An understanding of these enablers underpins this study's investigation into the factors that pharmacists in Wales identify as critical for the successful adoption of digital technologies.

The insights gained will inform strategies to support workforce development, service transformation and the advancement of digitally enabled pharmacy practice.

1.7 WELSH HEALTHCARE CONTEXT

The focus on Wales as the research setting provides a unique opportunity to examine the implementation of digital technology and AI within a specific healthcare context, bridging the gap between general literature on barriers and facilitators and the practical realities of the Welsh healthcare landscape.

The healthcare system in Wales operates under NHS Wales, which has its own distinct set of policies and priorities. Understanding this specific context is essential for comprehending the distinctive challenges and opportunities in the delivery of healthcare and implementation of policies in Wales. Furthermore, studies carried out within the Welsh healthcare environment can offer significant insights into small healthcare systems and their influence on digital strategy and healthcare innovation.

Digital health in Wales is recognised as a critical enabler to drive the techno-cultural change required to transform healthcare delivery (Hoban *et al.*, 2024). The Welsh Value in Health Centre (WVHC) advocates for a data-driven and digitally enhanced approach to inform decision-making across various levels, ranging from patient consultations to service quality enhancements, resource distribution and research purposes (Lewis, 2022). A comparative study by Hoban *et al.* (2024) between the Welsh and Australian healthcare systems underscores the importance of a well-coordinated and integrated digital health infrastructure. The research findings suggest that NHS Wales possesses an advantage over its Australian counterpart, owing to its capacity to produce and distribute national digital dashboards amongst a limited number of organisations. This capability facilitates more transparent and real-time access to health-related data.

The digital capabilities of Wales are not only impacted by its size but its predominantly rural landscape. These geographical constraints necessitate innovative approaches to healthcare provision, including the utilisation of telemedicine and outreach medical units. One of the primary obstacles in rural healthcare, as highlighted by Senbekov *et al.* (2020), is guaranteeing

that individuals in remote and countryside areas can access health services. Le Roux-Kemp (2023) notes that the use of telemedicine and telehealth services increased substantially during the COVID-19 pandemic. Nevertheless, healthcare professionals and patients frequently cite technical challenges such as poor connectivity, cost concerns and unreliable local networks as major impediments to the use of digital health technologies in rural regions (Borges do Nascimento *et al.*, 2023).

Brady *et al.* (2024) emphasises the importance of a sufficiently funded digital strategy in healthcare to facilitate the adoption and integration of digital technologies into organisations and healthcare systems. In Wales and the UK, the topic of healthcare funding for digital technology systems and projects has been a subject of considerable debate (Hutchings, 2020; Hammerton, Benson and Sibley (2022). Research has indicated that new central funding for NHS England is essential to support digitisation across the secondary care sector and ensure the adoption of electronic health records in GP practices (Watcher, 2019). NHS England was allocated a £3.4bn investment over three years by the UK government to enhance productivity through digital transformation. However, Appleby, Leng and Marshall (2024) report that this substantial sum would not address the deficit faced across the health sector. In Wales, as healthcare is a devolved matter, the Welsh Government responded to the UK government's announcement by allocating a short-term funding allocation to NHS Wales for 2024-25, although they did not explicitly specify the need to focus on digital advancements. This is however inconsistent with their own digital and data strategy (Welsh Government, 2021a) which emphasises the necessity of establishing a framework for multi-year operational investments to continuously improve technology and digital infrastructure and support digitally-enabled service change.

Within Wales, the pharmacy profession's own strategy, 'Pharmacy: Delivering a Healthier Wales' (PDaHW), was developed by the Welsh Pharmaceutical Committee, the professional leadership body for pharmacy in Wales and a statutory advisory committee to the Welsh Government. The document establishes several objectives for 2030 pertaining to technology and innovation, including the digitalisation of all prescribing and administration of medicines in Wales and utilising the potential of AI to enhance patient health and medicines outcomes (Welsh Pharmaceutical Committee, 2019). In order to support these strategic objectives for

the profession in Wales, the views pharmacists of potential barriers and facilitators for implementing digital solutions in pharmacy and the impact on the workforce are valuable. Furthermore, their priorities for future advancements developments will assist the development of future digital strategies for the wider healthcare system.

Examining the distinctive structure, funding environment and digital health strategies of NHS Wales is critical to this research. It ensures that the findings are firmly grounded within the Welsh context and enables the identification of specific priorities and challenges for pharmacy digital transformation.

1.8 RESEARCH AIMS AND OBJECTIVES

This study aims to critically explore the perspectives of expert pharmacists on the impact of emerging technologies on contemporary pharmacy practice, situated within the distinctive organisational and policy landscape of the Welsh healthcare system. Within the study there are a number of research objectives which will be addressed through different approaches. These are summarised in Table 1 below.

Table 1. Summary of research objectives and methodological approaches.

Research Objective	Research Method
Analyse and synthesise published research that examines pharmacists' attitudes towards digital technology, automation and AI.	Scoping Literature Review
Assess pharmacists' opinions regarding the potential for digital technology, automation and AI to either replace or assist with pharmacy functions and duties by the year 2030.	Original Delphi study
Ascertain pharmacists' priorities concerning future technological advancements in their practice in Wales.	Original Delphi study
Critically explore pharmacists' views on the potential impact of digital technology, automation and AI on the pharmacy workforce in Wales.	Original Delphi study
Critically examine the factors that pharmacists believe may facilitate or impede the implementation of digital technology, automation and AI in pharmacy practice in Wales	Original Delphi study

The study will use the Delphi methodology to examine the opinions of experts in the field of Pharmacy in Wales. This technique is useful to systematically building consensus opinion in areas where knowledge is limited (Nasa, Jain and Juneja, 2021). The wealth of experience

and expert knowledge that the participants bring to the study, provides rich yet manageable dataset from a relatively small panel size (Okoli and Pawlowski, 2004).

The findings from the research will lead to series of recommendations for the pharmacy profession and other healthcare organisations in Wales to be used to inform service prioritisation, strategic planning and development of pharmacy education in Wales.

1.9 CHAPTER SUMMARY

In summary, this chapter has established the context and rationale for the study and outlines the research aims and objectives underpinning the study. The chapter has provided an overview of pharmacy practice in the UK, alongside a comprehensive summary of the advancements, challenges and implications associated with digital technology, automation and AI within the pharmacy sector. It highlights the transformative potential of digital health solutions, including telemedicine, wearable devices and AI, in enhancing patient outcomes and improving healthcare efficiency. The integration of data-driven approaches into pharmacy practice can enhance disease diagnosis, treatment personalisation and preventive care, thereby contributing to a more patient-centric healthcare system. However, critical challenges such as infrastructure, data security and regulatory compliance persist.

The next chapter presents the literature review that has been undertaken to ascertain the current research on pharmacist attitudes towards digital technology, automation and AI. The chapter includes the systematic approach that was used to conduct the scoping literature review, including the search strategy, inclusion criteria and data extraction methods. It presents an analysis of the relevant studies, highlighting key themes and identifying potential gaps in the existing body of knowledge and providing the foundation for the subsequent research methodology.

Chapter 2. Literature Review

2.1 INTRODUCTION

A literature review serves as a critical foundation for any research project, offering a structured synthesis of existing evidence and enabling researchers to position their work within the current academic discourse (Aveyard, Payne and Preston, 2021). For this study, a scoping review methodology was selected as it facilitates the synthesis of a broad range of evidence from diverse sources in order to provide a thorough overview of the existing literature on pharmacists' perceptions of digital technology, automation and AI. Scoping reviews are particularly valuable in emerging and interdisciplinary fields, where evidence may be fragmented or heterogeneous. This review was conducted in accordance with the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines (Tricco *et al.*, 2018), ensuring methodological transparency and rigour throughout the identification, selection, and synthesis of literature.

An indicative review was initially undertaken in January 2023 as part of a DProf module to inform the design of this research project. Searches across MEDLINE (via Ovid), Embase (via Ovid) and the Cochrane Database of Systematic Reviews, supplemented by Google Scholar®, revealed limited original research specifically focused on pharmacists' attitudes towards digital innovation. While a considerable volume of opinion pieces and speculative literature addressed the future of technology in pharmacy, robust primary research capturing the perspectives of pharmacy professionals was limited. Expanding the search to include the views of other healthcare professionals revealed a larger body of original studies detailing their predictions for future digital healthcare developments and proposed timescales for implementation.

This chapter presents the findings of a PRISMA-guided scoping review, with the aim of critically synthesising current evidence on pharmacists' perceptions of digital technology, automation and AI. It also seeks to identify key enablers and barriers to implementation, as well as any gaps in the literature, particularly with regard to pharmacy-specific and UK-based contexts. By examining overlaps and distinctions between pharmacy and other healthcare

professions, this chapter establishes a clear rationale for the current study and its focus on pharmacists' preparedness for digital transformation within the NHS in Wales.

2.2 LITERATURE REVIEW METHODOLOGY

A scoping review methodology was chosen as it facilitated the identification and exploration all available literature, enabling a systematic approach to mapping and summarising the evidence to identify knowledge gaps and inform future research (Tricco *et al.*, 2018; Peters *et al.*, 2020). Although similar to a systematic review, the purpose of a scoping review is to “map the literature and provide an overview of evidence, concepts, or studies in a particular field” (Pollock *et al.*, 2021, p. 2102) rather than provide a summary of the best available evidence to address a pre-defined question (Aveyard, 2023).

This scoping review has been conducted in accordance with the Joanna Briggs Institute (JBI) methodology for scoping reviews and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping reviews (PRISMA-ScR) guideline (Moher *et al.*, 2009; Peters *et al.*, 2020). The scoping review is not limited to published research studies, and the search strategy aims to encompass all available literature including unpublished studies, policy documents, healthcare management publications and professional body websites.

2.2.1 Key Words and Search Strategy

Searching the literature is a fine balance between sensitivity and specificity. Sensitivity for a topic is the proportion of relevant studies as a percentage of all the relevant studies in existence, whereas the specificity is the proportion of relevant articles as a percentage of the number of articles retrieved. The search needs to be sufficiently sensitive to gather all the relevant data but also specific to the topic, so the researcher is not overwhelmed with articles (Khan *et al.*, 2003; Aveyard, Payne and Preston, 2021).

The research articles identified through the preliminary review were instrumental in determining relevant key words and index headings to inform the subsequent search. The research aims were also deconstructed into relevant concepts utilising the Population

Exposure Outcome (PEO) Framework, which has been cited as particularly useful for qualitative research questions (Bettany-Saltikov and McSherry, 2016; Davies, 2019). The keywords identified are presented in Table 2 overleaf.

Table 2. PEO framework to identify search keywords

Population	Exposure	Outcome
Pharmacists	AI, digital technology and automation in pharmacy	Attitudes
Keywords		
Pharmacy, Pharmacist, Pharmacists	Artificial intelligence, AI, machine learning, natural language processing, automation, digital technology	Attitudes, opinion, views

As recommended by Pollock *et al.* (2021), the advice and expertise of a senior health librarian was sought to inform the development of the scoping review strategy and identification of relevant databases. To ensure equivalence across each search, the approach was adapted for the different databases, to accommodate variable keywords, subject term descriptors and processes. Relevant Boolean operators were used to combine the search results.

Four electronic databases were searched for records from inception to 22nd January 2025: MEDLINE via Ovid, Embase via Ovid, CINAHL Plus via EBSCOhost and Cochrane Database of Systematic Reviews via Wiley. Results were limited to English language studies only. A search of the grey and unpublished literature was conducted using TRIP Pro, the Health Management Information Consortium (HMIC) and Proquest Dissertations and Theses Global. All searches were last conducted on the 22nd January 2025. No date limit was applied. Again, results were limited to English language only. Full details of the search strategies are presented in Appendix a. Furthermore, the reference lists and citations used in the selected studies were screened to identify any additional relevant studies. These supplementary studies were thoroughly examined and incorporated into the review if deemed pertinent.

Given the rapidly evolving landscape of healthcare technology and the increasing interest in applications within pharmacy, it was necessary to employ an iterative approach to the literature review and search strategy throughout the research. This approach entailed conducting new searches on a cyclical basis throughout the research project, ensuring the

reference list was comprehensive and any newly published studies in the field were incorporated as they were published. This review includes records up to the 22nd January 2025.

2.2.2 Evidence Selection and Data Extraction

All identified records from the different search strategies were collated and uploaded into the reference manager software EndNote21 (Clarivate Analytics, PA, USA) and duplicate records were removed from the list using the software functionality. The results were subsequently exported for manual screening by the researcher. The titles and abstracts of the records were reviewed to exclude those which did not meet the inclusion criteria. A full review was then conducted of the relevant resources that were accessible to the researcher online. Microsoft Excel was used by the researcher to facilitate the screening process and record notes on the papers.

2.2.3 Inclusion and Exclusion Criteria

To ensure a focused literature review, it is crucial to establish clear and precise inclusion and exclusion criteria (Aveyard, 2023). Table 3 outlines the criteria for the review, framed around participants, concept, context and types of sources.

Table 3. Inclusion and exclusion criteria for the literature review.

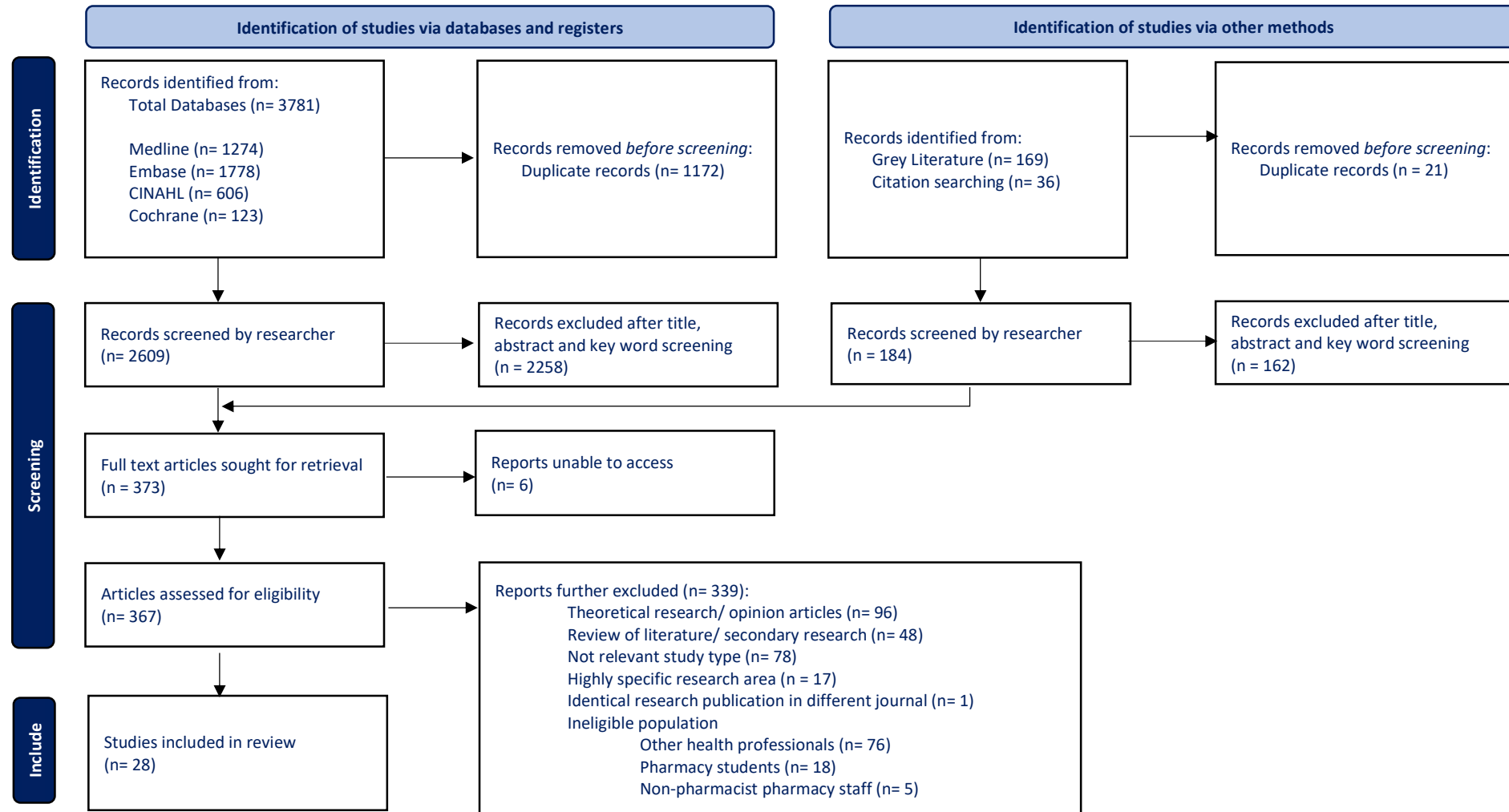
Inclusion criteria	Description
Participants	Articles which include pharmacists or pharmacy professionals
Concept	Studies that include digital technology, automation or artificial intelligence in respect to pharmacy
Context	All countries were included as the indicative search found limited studies in Wakes and the UK Studies published in the English language
Types of sources	Primary, secondary and tertiary sources Qualitative, quantitative and mixed methods studies
Exclusion criteria	Description
Participants	Articles which do not include pharmacists Articles which only include pharmacy students. Articles which only include non-pharmacist staff working in pharmacies (e.g., pharmacy technicians, pharmacy assistants and counter assistants)
Concept	Studies that explore pharmacists' opinions of matters other than relating to digital technology, automation or artificial intelligence in pharmacy
Context	Studies not in English language
Types of sources	Literature reviews Opinion/ trade articles

2.3 RESULTS

Figure 1, presented on the following page, depicts the number of papers identified, screened, excluded and included in accordance with the PRISMA guidelines (Moher *et al.*, 2009). Initially, 3781 records were identified through database searches. After de-duplication using EndNote21 software, the titles and abstracts of 2609 articles were manually screened by the researcher, resulting in 351 records deemed potentially eligible. An additional 205 records were identified for screening from grey and unpublished literature and citation examination. This number was reduced to 22 following the removal of duplicates and abstract screening. Subsequently 373 records were identified for full-text screening.

Upon reviewing the research papers, 339 studies were excluded for various reasons, including being secondary research, having an irrelevant research focus, involving an ineligible participant population (e.g., pharmacy students, other healthcare professionals, or pharmacy technicians and assistants), or addressing highly specific research areas (e.g., the use of AI in Radiation Oncology (Netherton *et al.*, 2021) or AI tools in antibiotic prescribing (Tiwari *et al.*, 2024)). Ultimately, 28 articles were included in the final literature review.

Figure 1. PRISMA flow diagram for scoping literature reviews including searches of databases, registers and other sources (Page *et al.*, 2021).
Literature Search= Views and Perceptions of Pharmacists on impact of digital technology, automation and AI/ML.



Of the 28 research studies included in the review, seven were based in Europe and four in the United States. Just over half of the studies only considered pharmacists perceptions (n= 14), while five included other pharmacy staff and eight other health care professionals. The majority of studies concentrated on a single sector of the profession: twelve on hospital, four on community pharmacy, one on education and academia, and eleven covered multiple sectors. Notably, there were no studies involving pharmacists based in primary care, general practitioner (GP) practices or other sectors. Table 4 shows the location, pharmacy sector and type of technology considered by the studies in this review. A summary with further detail of the individual studies' characteristics is provided in Appendix b.

Table 4: Summary of location, technology and pharmacy sector of studies included in literature review.

Location	no	Technology	no	Sector	no
United Kingdom	5	AI	10	Hospital	12
United States	4	Automation	8	Multi	11
Saudi Arabia	3	Digital- e-prescribing	4	Community	4
Jordan	2	Digital- EHR	3	Education/ Academia	1
Nigeria	2	Digital- telehealth	2		
Australia	1	Digital- CDS	1		
Canada	1				
Egypt	1				
Greece	1				
Indonesia	1				
Ireland	1				
Malaysia	1				
Middle East	1				
Pakistan	1				
Portugal	1				
Spain	1				
UAE	1				

In total, ten studies examined pharmacists' perspectives on digital technology, encompassing telehealth, electronic prescribing, electronic health records (EHR), and clinical decision systems. Eight studies focused on pharmacy automation, while ten investigated AI in pharmacy practice. The subsequent section delves into a detailed exploration and

comparison of the findings from studies that assessed pharmacists' views on these various technological domains and their impact on professional practice.

2.3.1 Automation

There are eight studies identified through the searches which consider pharmacists' views on automation. Of these, seven are conducted within the hospital sector, while only one study focuses on community pharmacy. This discrepancy may be attributed to the more extensive and longstanding implementation of automation in larger hospital dispensaries.

One of the earliest studies included in this literature review is a study from the United States by Crawford *et al.* (1998). This first study surveys pharmacy staff working in a large Mid-Western university hospital to determine their attitudes towards the utilisation of dispensing robots prior to the implementation of an automated system. The majority of staff express favourable attitudes concerning job security prospects and do not perceive that the use of robots will threaten their positions. However, the study highlights that individuals in non-pharmacist roles are less convinced of the benefits, which may be attributed to the prevalent belief among respondents that pharmacy technicians would be the most negatively impacted by the technology. This tension reflects broader concerns noted in sociotechnical literature, where automation is often seen to disproportionately affect lower-skilled workers. Importantly, the study identified insufficient communication as a key driver of resistance, underscoring the critical role of comprehensive communication strategies in technology implementation and the necessity to involve all staff in the early planning and decision-making stages to mitigate anxiety and minimise unsubstantiated information. The study suggests that the success of technological change depends not only on the technology itself but on how well it is socially embedded. However, the study's relevance to contemporary pharmacy practice is limited by its age, as today's pharmacy workforce is likely to be more technologically literate in both their professional and personal lives.

The second and third automation studies included in the review are conducted in Nigerian hospital pharmacies (Afolabi and Oyeibisi, 2007a and 2007b). Afolabi and Oyeibisi (2007a) focuses on pharmacists' perceptions of potential barriers to the implementation of

automation in three hospital pharmacies. The findings reveal that while pharmacists acknowledge the potential benefits of automation, many perceive the innovation as a threat to their job security and express inherent fears about the feasibility of automation in their own hospital setting. Interestingly, while most pharmacists are proficient in computing and basic concepts of pharmacy, pharmacists with higher computer literacy expressed fewer concerns. The analysis may not be conclusive of the effect of computer education on pharmacists' attitudinal disposition to the new technology, but the results suggest a potential moderating effect of digital confidence on technology acceptance and the need to incorporate automation concepts into undergraduate education programs and enhanced training for practicing pharmacists.

Afolabi and Oyeibisi (2007b) analyses data from the same survey of pharmacists working in three Nigerian Teaching Hospitals, to investigate the attitudes of hospital pharmacists towards the incorporation of automation into pharmacy services. The study reveals that pharmacists possess a comprehensive understanding of various forms of automation in pharmacy operations and believe that automation will have a positive impact on their functions, including dispensing, drug inventory management and administrative tasks. They anticipate automation allowing pharmacists to allocate more time to clinical decision-making, patient monitoring and information provision. The study again emphasises the importance of appropriate training workshops, continuing education programmes and exposure to evolving automation strategies to equip pharmacists with the requisite skills to manage automated pharmacy systems effectively in the future. While both studies provide valuable insights into hospital pharmacists' perspectives on automation, they were conducted within a healthcare system that differs significantly from that in Wales and the UK, which may limit their generalisability. Moreover, their reliance on self-reported attitudes, without long-term follow-up or outcome data, weakens the strength of their conclusions. Additionally, these studies were conducted some time ago; therefore, pharmacists' views may have evolved over time with increased exposure to automation technology.

The fourth study included is the only research paper from Wales considered in the literature review. James *et al.* (2013b) investigates the psychological effects of automation technology

on hospital pharmacy staff. This longitudinal case study utilises a combination of an anonymous occupational stressor questionnaire and focus groups to gather data both before and after the implementation of automation. It is among the few articles that reference the principles of socio-technical research, examining the interplay between social and technical elements. The study highlights the importance of aligning technology with the needs of pharmacy staff and cautions that any misalignment could result in diminished efficiency, safety and service quality, as well as low morale, job dissatisfaction, absenteeism and high staff turnover. Nevertheless, the study finds positive effects of automation on pharmacy workload management and work-life balance. Additionally, there are favourable perceptions regarding the post-automation effects on career development and job satisfaction. Participants also believe that automation elevates the profile of the pharmacy, potentially aiding in recruitment and retention. However, the introduction of new stressors, such as robot malfunctions and increased pressure due to reduced staffing, is noted. Further negative effects, including decreased teamwork and some technicians feeling devalued by the system, are observed. These findings echo earlier concerns raised by Crawford et al. (1998), reinforcing the idea that automation can generate both functional benefits and psychosocial risks.

Although the study is a small case study, it holds relevance to this research project due to its setting in Wales. However, the low response rate and the two-year interval between pre- and post-automation data collection may have compromised the reliability of the findings. Surprisingly, 31 staff members from the initial observations remained employed in the same roles when the researchers returned, rendering them eligible for inclusion in the longitudinal study. Nevertheless, their anonymous responses were not linked, precluding the possibility of comparing individual response changes over the study period. The study did not account for the increased number of dispensary lines and the rising complexity of treatment regimens over the two years, therefore a review of the hospital formulary differences during this period would have been beneficial. Additionally, the use of focus group discussions may have influenced pharmacy staff's reluctance to candidly express their opinions on the impact of automation on occupational stressors, particularly in the presence of senior staff.

The fifth study by Rodriguez-Gonzalez *et al.* (2018) is a post-implementation study in an outpatient hospital pharmacy in Madrid. It reveals positive benefits to automation, including a significant decrease in dispensing errors and positive impact on staff satisfaction, although technicians express lower satisfaction with automation compared to pharmacists, echoing the pre-automation concerns expressed in the earlier study by Crawford *et al.* (1998) and raising questions about how different professional groups experience automation. However, both pharmacist and technician groups express a preference for the robotic system over manual dispensing and are inclined to recommend it to others. The study participants identify several factors that facilitate the adoption of the technology, such as the user-friendly nature of the machine and its software, efficient dispensing process, availability of technical assistance, training and contribution to safety. There are certain limitations to the study design to acknowledge, such as the potential bias introduced by the Hawthorne effect in observational studies. The study's single-site design may reduce the generalisability of the findings to other healthcare settings or regions. Additionally, the variation in staff surveyed at different stages, attributable to the high turnover rate among hospital pharmacy personnel, must be considered. Nonetheless, the findings are significant in highlighting that multiple factors influence staff satisfaction with automation technology, which subsequently affects their willingness to adopt and support the change.

A sixth study conducted in the UK by Van der Meer *et al.* (2013) examines the effects of a large-scale automation initiative on pharmacy staff across four hospital pharmacies within a major health authority in Glasgow. The research is pertinent to the current project as it is conducted within the UK, and the NHS in Scotland exhibits a similar integration of hospital and primary care services as observed in the Welsh healthcare context. The researchers have conducted interviews with staff to gather insights into their initial experiences with a pharmacy redesign program that centralised the storage and supply of medicines at an off-site facility. The hospital pharmacy staff report several challenges associated with the technology, including order errors due to malfunctions in the conveyor system, issues with the pharmacy management system and difficulties in sourcing unavailable medicines. During these early stages of implementation, morale is notably low, with staff expressing uncertainty about their roles and management communication, as well as feeling conflicted between the

new system and patient care standards. Local work-around solutions have emerged to address system deficiencies; however, these lead to unintended consequences, such as increased workload and strained communication. The findings indicate significant unease among the pharmacy staff at the onset of the automation project. Nevertheless, the researchers note post-study that these concerns gradually diminish over time, with reported advantages including improved utilisation of floor space, enhanced patient safety and increased efficiency in pharmacy services. The study indicates that if initial implementation challenges are effectively addressed and staff are fully engaged in the transformation process, early-stage resistance can evolve into acceptance, a key recommendation for iterative change management.

The seventh and final pharmacy automation study based in hospital (Ramachandram *et al.*, 2023), examines the effects of pharmacy automation on the workload and job satisfaction of pharmacists and pharmacy assistants within an inpatient hospital environment in Malaysia. This small-scale study reveals that automation has a favourable impact on the workload of pharmacy staff and decreases medication handling time. The findings indicate that the majority of pharmacists express confidence in the automated dispensing system, acknowledging its advantages for patients and its role in reducing medication errors. Importantly, both pharmacists and pharmacy assistants report high levels of job satisfaction, with automation providing pharmacists with increased opportunities to train new staff and concentrate on clinical activities such as prescription review, consultation with healthcare providers and identification of critical drug interactions. Additionally, the study finds ongoing challenges faced by staff, including excessive workload and the need for further education and training in equipment handling and maintenance. These results highlight the risk of assuming that automation automatically frees time for clinical care, when in practice, structural and workload constraints may persist.

The literature search found only one study exploring the opinions of community pharmacy staff regarding the impact of dispensary automation on their roles and job satisfaction. Cavaco and Krookas (2013) have conducted a cross-sectional investigation in ten Portuguese community pharmacies, both equipped with and without automation, to evaluate the job

satisfaction levels of pharmacists and technicians, as well as the duration of patient interactions for counselling and medicines advice. The findings reveal that automation in community pharmacies did not significantly improve job satisfaction or increase the time available for staff to improve patient-orientated practice. This contrasts with hospital-based findings and underscores the importance of contextualising automation impacts within sector-specific models of care. The authors find high levels of job satisfaction are associated with more work variety and extended patient counselling beyond traditional dispensing tasks suggesting that the value of automation is contingent not just on technology adoption but on how it enables meaningful professional engagement. Limitations of the study include potential bias due to observer presence and the inability to control for all confounding factors influencing the results.

The studies collectively examine the perspectives of pharmacists and pharmacy staff regarding the impact of automation on their services across various healthcare settings. Although most are conducted outside the UK, there are many transferable insights for pharmacy in Wales. While there is broad agreement on the operational benefits of automation, the evidence also highlights uneven impacts across roles, sectors and implementation contexts. Importantly, studies that engage with sociotechnical and change management perspectives emphasise staff engagement, communication and organisational readiness are critical to success. Furthermore, the studies emphasise the significance of a carefully managed, inclusive approach to automation implementation that considers both technical functionality and human factors.

2.3.2 Digital Technology- Electronic Prescribing

Several qualitative studies were found that explore pharmacy staff views and experiences with electronic prescribing (e-prescribing) systems in different healthcare settings. While these studies individually offer insights into the implementation and impact of such systems, a critical comparison reveals shared enablers and persistent challenges that must be addressed to facilitate effective adoption.

In the first study, Mehta and Onatade (2008) investigate the experiences of pharmacy staff across seven UK NHS hospitals using telephone interviews to understand how inpatient e-prescribing systems impact on pharmacy work and the perceived advantages over manual systems. According to respondents, e-prescribing generally has a positive benefit on pharmacy. Pharmacists describe benefits including enhanced patient safety (through features like allergy documentation), the ability to prioritise patients prior to ward rounds through remote access and the ease of identifying their clinical contributions via system analytics. Desired developments for the future include full clinical decision support, formulary integration and mandatory allergy status documentation. However, concerns are expressed regarding the decrease in face-to-face patient contact due to remote access capabilities, as well as the significant and underestimated training requirements and need additional staff support during the implementation phase. These findings illustrate a key tension in digital transformation, where remote access can optimise time and resources, it may unintentionally undermine relational aspects of patient-centred care. Furthermore, the training demands highlighted here suggest that digital system implementation must be paired with substantial workforce support and digital upskilling strategies

A second UK study, conducted by Mills, Weidmann, and Stewart (2017), evaluates the impact of a Hospital Electronic Prescribing and Medicines Administration (HEPMA) system implementation discharge information dissemination and staff behavioural changes in one NHS hospital. The research explores the views of pharmacists (n=6) and other healthcare professionals (n=19) before and after the implementation, through qualitative interviews and behavioural analysis. A notable limitation of the study was that many of the original staff were unavailable post-implementation (all the pharmacists were different in both rounds), which raises questions about the reliability of the findings. Prior to implementation, staff identified issues with illegible and inaccurate information in inpatient charts and discharge letters. Post-implementation, significant improvements are observed in inpatient chart clarity and discharge letter quality. Interprofessional variation in the acceptance of the HEPMA system is evident, with the system being generally well-received by most staff and notably enhancing the confidence and roles of non-medical prescribers. However, some consultants exhibit resistance to its use. The lack of investigation into the underlying causes

of this resistance represents a missed opportunity to explore the professional, cultural and hierarchical barriers that frequently affect technology adoption within multidisciplinary teams.

A qualitative study by Hogan-Murphy *et al.* (2021) utilises semi-structured interviews to investigate the barriers and facilitators for implementing a range of electronic systems for managing medicines in three Irish hospitals. These include electronic prescribing, robotic pharmacy systems and automated medication storage units. Although this study is limited to three hospitals, the Irish healthcare system bears similarities to that of Wales, and the study provides valuable insights into the socio-organisational complexities surrounding digital adoption. The study identifies enhanced patient safety and efficiency in healthcare delivery as key drivers for system implementation. Furthermore, individual training, clinical champions and a multi-disciplinary implementation team are identified as essential to promote engagement and cognitive participation. Conversely, significant barriers to implementation in the Irish hospitals include inadequate training, hardware and network issues, altered working practices, poor understanding by health professionals and a lack of organisational support. Participants express concerns regarding workflow issues, time delays, and inadequate resources, all impacting the usability of electronic systems compared to manual practices. These findings echo key themes in sociotechnical theory, underscoring the importance of aligning technological systems with user workflows, interprofessional relationships and local resource capacities.

The fourth and final study in this section considers the perceptions of primary healthcare professionals regarding the national e-prescribing system in Greece. Grammatikopoulou *et al.* (2024) conducted a survey involving 430 healthcare professionals, including 137 community pharmacists, using an online questionnaire with both closed- and open-ended questions. The respondents highlight the positive impact of e-prescribing in reducing medication errors and automating the prescribing process. However, they suggest further enhancements to the system to improve patient safety by increasing access to information on adverse drug reactions, side effects, drug interactions and allergies. The findings also highlight the necessity of linking e-prescription systems to patients' electronic health records

and the importance of integrating therapeutic prescribing protocols for effective monitoring and decision-making. Participants also identify issues such as unclear dosing instructions, missing information on adverse drug reactions. Although a Wales-wide e-prescribing system does not currently exist, this large-scale study offers valuable insights into primary care professionals' perspectives on e-prescribing, which could inform future system developments in the country.

In summary, while each study provides distinct insights into e-prescribing systems across various healthcare environments, collectively, they highlight the transformative potential of e-prescribing systems in enhancing medication safety, communication and efficiency but also illustrate the layered complexities of implementation. Importantly, these studies highlight the need for digital systems to be embedded not only technologically but also socially, through collaborative design, shared ownership, user feedback and iterative refinement, taking an inclusive, multidisciplinary change management approach.

2.3.3 Digital Technology- Electronic Health Records

There were three studies identified in the literature exploring the perspectives of pharmacists and physicians of electronic health records (EHRs) and the impact on their practice. They reveal a number of potential benefits of EHRs but also intrinsic structural and systemic challenges that undermine their impact across healthcare systems.

Mercer *et al.*'s (2018) mixed-methods study of primary care physicians and community pharmacists from Canada, reveals that both groups of health professionals work independently of each other, due to the different electronic patient information systems used and their limited interoperability. Medication-related decisions are made autonomously based on their own information and understanding of the patient. Communication between the professions was found to be indirect, often relying on patients, faxes or receptionists. Their findings suggest that the potential benefits of electronic patient records are severely limited by the lack of integration and interoperability between different healthcare providers' systems. The study illustrates that fragmentation hinders effective communication and health professionals are unable to establish trusting relationships and unwilling to share

information about their decision-making with respect to medication management. This aligns with sociotechnical perspectives that stress the need for integrated systems designed with collaborative workflows.

A second study of health records (Kosari *et al.*, 2020), examines the perspectives of 63 pharmacists during the implementation of the Australian digital health record system, My Health Record (MHR). The system provides a summary of an individual's health information and can be used by a range of health professionals and also accessed by patients. In contrast to the previous study, this research reveals predominantly favourable views towards MHR. Participants believe it will likely reduce errors, enhance patient care, foster better collaboration among healthcare professionals and improve patient satisfaction. However, some pharmacists express concerns about patient privacy, lack of training, access to the system and the accuracy of information within MHR. The finding that younger pharmacists exhibit higher levels of satisfaction implies that generational shifts in digital literacy may play a role in shaping the trajectory of technology acceptance. The study supports the idea that digital health initiatives must be supported not only by infrastructure but also by tailored training and trust-building strategies.

For the third study, Tolley *et al.* (2023) employ in-depth, structured interviews with 21 pharmacists (from different sectors) and two GPs in the north of England to explore the challenges and opportunities associated with transferring medication information between care settings and utilising digital tools to enhance medication management. The findings reveal complexities in managing various medication management systems across the region, along with issues related to incomplete patient records and barriers concerning digital tools like multiple systems, interoperability and gaps in data availability. Participants stress the need for a consolidated integrated health record accessible across different care sectors for improved patient care. Recommendations include developing standardised digital information standards, better IT system management and promoting collaboration among stakeholders.

Overall, the study highlighted the necessity for effective digital solutions to enhance medicine management across care settings and ensure patient safety and efficient care delivery. While the study sample is small, the demographic and infrastructure characteristics of the region are likely to be similar to that in Wales, lending its findings relevance to Welsh policy planning.

In summary, the first study highlights the lack of collaboration and information sharing between pharmacists and physicians as a barrier to effective decision-making. This finding aligns with the concerns raised by pharmacists in the second study regarding the accuracy of information within electronic health records and the need for better support and training to integrate the system into their workflows. The third UK based study reveals the different complex systems that currently hold medicines management across healthcare settings and the related challenges impacting on effective communication and collaboration between healthcare professionals. While the healthcare systems in Canada, Australia and the UK share similarities, the third paper based in a region of the UK is more applicable to the current study in Wales. The long-awaited implementation of integrated health records into NHS Wales could potentially improve medicines management across the interfaces and enhance the safety and quality of patient care. However, it is essential to consider the unique aspects of the Welsh healthcare system, including its organisational structure and existing digital health initiatives led by DHCW.

2.3.4 Digital Technology- Clinical Decision Support

Hines *et al.* (2011) have conducted a study evaluating pharmacists' awareness of clinical decision support (CDS) functionalities in pharmacy information systems, with a particular focus on drug-drug interactions (DDI) and other medication-related features. This qualitative study, involving on-site interviews with 61 pharmacists from various sectors in Arizona, reveals that while most systems offered basic alerts for allergies and DDIs, awareness of more advanced features, such as drug-disease interactions, age-specific alerts or laboratory recommendations, is limited. The finding that pharmacists are often unaware of the full scope of their system's capabilities suggests a critical disconnect between technological potential and end-user engagement. This aligns with broader concerns in health informatics

about the underutilisation of embedded tools due to insufficient training or system complexity.

Approximately 60% of pharmacists report that their systems provide management guidance alongside interaction alerts and many systems are capable of incorporating medications from external sources, including other pharmacies and over-the-counter purchases. However, more advanced functionalities, such as paediatric dosing and laboratory recommendations, were underutilised or absent. The study's recommendation for enhanced informatics education is both timely and enduring, despite the age of the data. While the pharmacy informatics landscape has evolved significantly over the past decade, the fundamental challenge of optimising CDS system use remains relevant. Inadequate user awareness, inconsistent interface design and alert fatigue continue to affect system effectiveness in many healthcare settings.

From a theoretical perspective, the study illustrates the implications of the Unified Theory of Acceptance and Use of Technology (Venkatesh *et al.*, 2003) particularly in how effort expectancy and facilitating conditions shape health professionals' engagement with digital CDS systems (Dingel *et al.*, 2024). If pharmacists are unaware of tool's capabilities, their perceived usefulness remains low, regardless of the technology's full potential and there is a missed opportunity to use the potential to improving medication safety. This study reinforces the need to ensure technological implementation is undertaken at the same time as ongoing development of digital literacy and system-specific training initiatives for users.

2.3.5 Digital Technology- Telehealth

Two studies evaluating healthcare professionals' (HCPs) knowledge, attitudes and barriers regarding telehealth services offer important comparative insights into the enablers and limitations of digital communication tools in pharmacy and wider healthcare practice. Wathoni *et al.* (2023) focuses on Indonesian pharmacists, whereas Alghamdi *et al.* (2022) encompass a broader range of HCPs in Saudi Arabia.

Wathoni *et al.* (2023) report a high knowledge, positive perceptions and moderate readiness among Indonesian pharmacists concerning telehealth or telepharmacy. However, some express concerns about the potential for increased error rates in medication dispensing via telepharmacy. Furthermore, while the study underscores the association between pharmacists' knowledge and their readiness to implement telehealth services, it advocates for the incorporation of telehealth training into pharmacy education curricula to better prepare future pharmacists. This recommendation, however, should be critically examined in light of potential challenges in integrating telehealth training into a full curriculum and varying educational standards across institutions. Key barriers identified in this study include increased workload and insufficient incentives, with many pharmacists expressing reluctance to engage in telepharmacy projects without appropriate compensation. This raises important questions regarding the sustainability of telehealth initiatives, particularly in resource-limited settings.

Alghamdi *et al.* (2022) present a varied picture of telehealth usage across the different professions surveyed in Saudi Arabia. Overall, nearly half of HCPs utilise telehealth, with pharmacists being comparatively high users (62%). Although many HCPs feel comfortable using telehealth and perceive it as useful to improve care quality delivery and patient access, the study identifies significant barriers, including time constraints, a lack of knowledge, trained staff and necessary equipment; as well as challenges related to patient cooperation and stakeholder support. While the findings suggest that telehealth adoption is progressing, these barriers point to deeper systemic issues within healthcare organisations, which must be addressed to ensure the successful implementation and sustainability of telehealth services.

Critically, both studies do not explore the long-term impact of telehealth on professional identity, clinical outcomes or patient equity. Neither study addresses how telehealth access may vary across geographical regions or socioeconomic contexts, thereby limiting the applicability of their conclusions to universal health systems such as the UK's NHS. Nonetheless, they both highlight the importance of enhancing awareness, knowledge and training programs for healthcare professionals to facilitate the effective adoption and

implementation of telehealth. They highlight the need to address barriers, such as time constraints and workload concerns, and collectively advocate for greater investment in digital literacy, infrastructure and supportive policies to facilitate telehealth innovation and adoption.

2.3.6 Artificial Intelligence

The literature search identified several studies conducted in the Middle East and Asia exploring pharmacists' perspectives on AI and its potential impact on their professional practice.

For the first study in this section, Abu Hammour *et al.* (2023) have surveyed community pharmacists in Jordan to evaluate the benefits and challenges associated with generative AI, specifically ChatGPT. While the majority of respondents recognise the tool's potential in marketing, education and customer support, its actual application in practice remains limited, with most pharmacists infrequently using it for tasks such as drug interaction checks or medication reconciliation. Despite concerns regarding privacy, bias and accuracy, pharmacists who utilise ChatGPT find it valuable, particularly in managing adverse drug reactions. The study highlights a positive correlation between AI usage and favourable perceptions; however, concerns about misinformation suggest the necessity for enhanced education on AI's capabilities. Nevertheless, the predominance of younger participants (83% between 20 to 30 years old) may limit the generalisability of the results to the broader pharmacist population.

Jaber *et al.* (2024) have conducted a broader survey of pharmacists working in different sectors of practice across in the Middle East. The study reveals varying levels of knowledge and attitudes towards AI. Whilst many are optimistic about AI's transformative potential, particularly in clinical pharmacy, their understanding of more advanced AI applications is limited, necessitating further education and training to fully integrate AI benefits into their workflows. The respondents express mixed attitudes regarding the potential replacement of healthcare professionals, suggesting that pharmacists value the human element in

healthcare. The study again emphasises the need for targeted education to interventions to integrate AI into pharmacy practice effectively.

A third research paper, from the United Arab Emirates (Jairoun *et al.* (2024), qualitatively investigates pharmacists' perspectives on ChatGPT. The researchers have interviewed 35 pharmacists from different sectors of practice, and identify both benefits, such as enhanced medication adherence and error reduction, and risks, including inaccurate information, legal and ethical concerns, technology dependency and reduced interactions with patients. The authors emphasise the necessity of evidence-based regulation and thorough validation of AI outputs in pharmacy settings.

In the fourth study, Jarab *et al.* (2023) examine community pharmacists' willingness to adopt AI in Jordan, finding high interest in using AI for tasks like medication-related problem identification and remote healthcare services. Many respondents indicate a desire to be informed about AI use, with only a minority expressing fear of job replacement. However, barriers such as the lack of AI infrastructure, high costs and the need for human oversight, are highlighted as significant challenges by the participants. Notably, the study reveals that pharmacists with more years of experience are more inclined to adopt AI than their less experienced colleagues. The researchers propose that pharmacists' increasing awareness of labour-intensive tasks as they gain experience might lead to a greater willingness to adopt AI to streamline these tasks. Despite the high reported enthusiasm, the study suggests that self-reported attitudes may not translate into actual adoption, potentially influenced by social desirability bias. Additionally, the absence of AI-related content in Jordanian pharmacy courses, acknowledged by the researchers, could significantly impact the validity of respondents' opinions on AI adoption.

Again, remaining in the community sector, the fifth paper by Syed and Al-Rawi (2024) surveys 273 community pharmacists in Riyadh, Saudi Arabia. The study reveals an overwhelming optimism about AI, with many believing it would improve healthcare efficiency, aid decision making and reduce medication errors. There is minimal concern expressed about job losses and replacement of healthcare professional. However, the study's youth-centric sample (97%

under 35) and the lack of female representation (8%) may limit its generalisability; with the results possibly reflecting a tech-savvy, male-dominated perspective rather than a broader pharmacist viewpoint.

Alanzi (2023) focuses on health care professionals' views of ChatGPT's role in teleconsultations in Saudi Arabia, noting its potential to improve the accuracy information and documentation, aid in diagnoses, enhance efficiency and communication, and support education. However, concerns about privacy, misdiagnosis and over-reliance on technology are prevalent, suggesting ChatGPT should serve as a supplementary tool, not a replacement to human judgement. This study has some limitations including the introduction of bias in the results through the influence of professional seniority on the opinions of other participants in the focus groups and, particular to this literature review, is the small number of pharmacists included in the study.

The seventh study by Taha *et al.* (2024), surveys 428 pharmacists from different sectors of practice in Egypt, highlighting both the potential benefits of ChatGPT, such as educational support, and concerns over data accuracy and bias. The study advocates for awareness campaigns, specialised training and regulatory guidelines to promote responsible AI usage within pharmacy practice.

Yousif *et al.* (2024) in Pakistan reveal that healthcare professionals generally possess limited knowledge of AI and its fundamentals, although pharmacists and physicians demonstrate greater familiarity compared to nurses. While participants express a willingness to adopt AI, they anticipate a gradual integration process and identify obstacles such as financial constraints, insufficient training and infrastructure limitations. They also highlight technological limitations, including AI's inability to comprehend human emotions and the risk of over-reliance on technology potentially affecting healthcare professionals' critical thinking skills, echoing Alanzi's (2023) earlier findings. The findings underscore the need for comprehensive strategies to address these challenges through the provision of extensive training programs for HCPs, increasing awareness among the public and healthcare

professionals, securing adequate funding and promoting research on AI applications in the healthcare context.

One of the two studies conducted outside of the Middle East and Asia (Gustafson *et al.*, 2024), surveyed 1363 pharmacists in the United States, revealing a familiarity with AI but limited usage in practice. Concerns about job displacement and trust in AI are widespread, but many are optimistic about AI's potential to enhance productivity and their professional roles. The study also identifies significant demographic differences in AI usage, with younger and male pharmacists more likely to embrace AI. Additionally, the study highlights barriers to AI implementation, including training and technical expertise, ethical considerations and regulatory issues.

The final study in this section is the investigation conducted by Smetana *et al.* (2024) into US pharmacists' perceptions of AI in educational contexts. This finds that the majority of pharmacists recognise AI's potential, particularly to analyse data, with more experienced pharmacists being more inclined to acknowledge these advantages. However, concerns about content accuracy, plagiarism and impact on human interactions persist. The study illustrates a nuanced landscape of enthusiasm and caution among pharmacists regarding the integration of AI in pharmacy education, highlighting the necessity for targeted educational strategies to enhance AI literacy and ethical use within this field.

Collectively, these studies indicate a generally positive attitude towards AI adoption by pharmacists and emphasise the potential benefits, including increased efficiency, improved patient outcomes and enhanced decision support. However, they also highlight the need for informed and responsible AI integration and underline the importance of addressing challenges such as job displacement concerns, accuracy issues, privacy risks and the need for comprehensive training and education. Applying the Unified Theory of Acceptance and Use of Technology (Venkatesh *et al.*, 2003), these findings suggest that pharmacists' performance expectancy is high, however the facilitating conditions and effort expectancy lag behind. It is important to note that the majority of the studies included have been conducted via online survey platforms, which could be criticised for introducing a selection bias towards

pharmacists who are already comfortable with digital technology. The predominance of studies from the Middle East and Asia limits the broader applicability of these findings, suggesting the need for more diverse, representative research to inform AI adoption in pharmacy across different regions and distinct healthcare systems in the UK and Europe.

2.4 CONSIDERATION OF THE WIDER LITERATURE FROM OTHER HEALTHCARE PROFESSIONALS AND STUDENTS

While not directly addressed in this review, numerous recent studies involving other health professionals and healthcare students' views on AI technology, reveal findings that are somewhat similar to those observed in the pharmacy research.

Research on the perspectives of UK pharmacy students regarding AI technology is limited, yet it is essential for adequately preparing the future workforce. The study of over 150 pharmacy students in Saudi Arabia by Syed and Al-Rawi (2023) reveals that 74% of the students were familiar with AI and 69% believed it aids healthcare professionals. However, these figures should be interpreted cautiously, as self-reported familiarity does not necessarily equate to actual knowledge or understanding of AI's capabilities and limitations in healthcare. Additionally, the study's generalisability is affected by its gender imbalance and limited age range, similar to their research on community pharmacists. The absence of formal AI education among 80% of participants is concerning, given the increasing significance of AI in healthcare.

Alsaali's (2021) research on pharmacy interns (pre-registration pharmacy graduates) in Saudi Arabia identifies a need for additional education and training in digital health applications. The findings reveal that whilst participants are well-versed in commonly used health apps in the country, a considerable number (64%) believe additional education and training is essential for pharmacists to effectively employ these tools in their work. Moreover, 67% of those surveyed concur that additional training on pharmacy informatics and digital health should be incorporated into the internship year to reduce medical errors and enhance the quality of care. Mosleh *et al.* (2024) examine medicine and pharmacy students in Jordan and

Palestine, finding high awareness of AI programs (81%) but limited practical application (44%). Pharmacy students primarily utilised AI for drug information and scientific writing tasks.

Of more relevance to pharmacy in Wales, Busch *et al.* (2023) conducted a multinational study of pharmacy students with over 70% of the respondents from Europe, revealing generally positive attitudes towards the integration of AI in pharmacy, with 58% of participants expressing favourable views. However, a notable gap exists between students' perceptions of AI's benefits and their preparedness to utilise AI technologies. The study underscores the necessity for comprehensive AI education within pharmacy curricula. Hasan *et al.* (2024) conducted research across six countries, identifying a discrepancy between the claimed familiarity with AI (93%) and the demonstrated understanding (40%). Pharmacy students exhibit higher AI knowledge scores compared to faculty members, indicating a potential generational gap in AI literacy. These studies consistently highlight a knowledge gap and a strong desire for increased AI education in pharmacy curricula. Addressing these educational needs is crucial as digital technology and AI continue to integrate into healthcare systems.

Several studies have examined medical students' perceptions and understanding of digital technology and AI in healthcare. The overall outlook remains largely positive, yet findings indicate variations in knowledge levels, concerns and attitudes across different regions and disciplines.

Boillat, Nawaz, and Rivas (2022) have investigated the perspectives of approximately 200 medical students and qualified doctors in the Middle East, revealing limited AI literacy and minimal participation in AI-focused training. Concerns are raised regarding algorithmic transparency and the need for robust regulatory frameworks to ensure safe usage. The researchers observed that students exhibited greater risk aversion compared to experienced professionals and qualified medical professionals felt less threatened and demonstrated a higher inclination to work collaboratively with AI. regulatory oversight, with medical students demonstrating greater risk aversion than experienced practitioners. Similarly, Bisdas *et al.*'s (2021) larger multinational study of over 3000 medical and dental students highlights disparities in AI knowledge based on gender and national development status. The study

reveals that most students relied on informal sources for AI information, underscoring the need for formal AI education within medical curricula.

In contrast, Oh *et al.* (2019) have surveyed medical students and doctors in Korea, reporting an optimistic perspective on AI, with the majority of respondents expressing favourable attitudes towards AI and minimal concern regarding job displacement. The participants indicate that AI would be most beneficial in diagnosing and planning treatments, as well as providing the latest clinically relevant data. A noteworthy finding was the risks of AI identified by the respondents, including the potential inability of AI to produce valid results in unexpected situations due to insufficient data and the possibility that AI might not be applicable to all patients.

In their study, Teng *et al.* (2022) examine a diverse cohort of Canadian healthcare students to offer insights for future curriculum development, identifying discipline-specific variations in perceptions of AI. Notably, final-year students demonstrated greater enthusiasm for AI compared to first-year students, while pharmacy students were relatively less optimistic about AI's impact within their field.

Closer to the UK, Blease *et al.* (2023) examine Irish medical students' views on AI in primary care. Their findings reveal that of the 252 participants, approximately two-thirds (63%) of the students believe AI will not fully replace general practitioners (GPs) in reaching diagnoses, but a significant proportion (86%) expect technology to undertake documentation tasks. More than half of the participants (52%) believe that AI and ML will have a moderate to extreme impact on the work of GPs in the next 25 years, while only 10% think that it would have no impact and the work of GPs will remain unchanged.

Notably, the researchers report that those students with no aspirations of pursuing a career in primary care believe that AI and ML will have a more significant impact. This study provides a valuable addition to the literature by introducing the concept of “self-preserving optimism bias” (Blease *et al.*, 2023, p. 5) to describe the tendency of individuals to underestimate the

impact of technological advancements on their respective chosen specialty. This could be transferrable to the profession of pharmacy but requires further validation.

Other studies of medical students have been primarily focused on their perceptions of AI's influence on their choice of career, mainly centered on the specialty of radiology. For instance, German undergraduate medical students do not seem concerned about AI replacing human radiologists (Pinto dos Santos *et al.*, 2019), while Canadian students believe it could decrease the demand for radiologists (Gong *et al.*, 2018). Students from the United States are less enthusiastic about radiology because of AI (Park, Paul, and Siegel, 2021) and British students report being less likely to pursue a career in radiology due to AI (Sit *et al.*, 2020).

Considering research of qualified healthcare professionals, the benefit of AI in the speciality of radiology in terms of diagnostic accuracy, pathological interpretation, quality control and predictive modelling is widely acknowledged (Letourneau-Guillon *et al.*, 2020; Barragan-Montero *et al.*, 2021; Okolo *et al.*, 2021; Seah *et al.*, 2022). Consequently, there have been a number of studies considering radiologists' understanding, attitudes and challenges surrounding its adoption in their practice. Surveys of radiologists and trainees in France (Waymel *et al.*, 2019), the US (Collado-Mesa, Alvarez and Arheart, 2018) and the UK (Hashmi *et al.*, 2023) show a high level of interest in AI integration and a belief that it will positively impact their future practice. However, most respondents report limited exposure to AI literature and a lack of adequate training in this field. Concerns about job replacement, system implementation and ethical or regulatory issues are also prevalent. The research highlights a near-unanimous belief among radiology trainees that AI should be included in training programs, with a focus on basic understanding, implementation and critical appraisal of AI software. Despite the growing interest, the studies show everyday use of AI in radiology practice remains low and there is an ongoing unmet need for more AI-based content and training in this field of medicine.

Recent studies have explored the perspectives of other medical professionals from various fields regarding AI. Cobianchi *et al.* (2023) note that although most surgeons are familiar with AI terminology, only a few possess a comprehensive understanding of AI concepts. These

surgeons tend to prefer AI as a tool for decision validation rather than as an autonomous decision-making entity. Similar findings are reported by Oh *et al.* (2019) and Polesie *et al.* (2020), who highlight the limited AI knowledge among medical professionals. Alanzi *et al.*'s (2023) investigation into AI implementation in family medicine in Saudi Arabia identifies key factors facilitating technology acceptance, such as peer opinions, tool simplicity and a supportive environment. Nonetheless, concerns about privacy and ethical issues are raised. Buck *et al.*'s (2022) qualitative study of German general practitioners (GPs) reveals inadequate AI literacy and identifies barriers to AI adoption, including perceived lack of necessity and aversion to technology.

One of the seminal studies which considers healthcare professionals predictions regarding the future impact on technology on their practice is Blease *et al.*'s (2018) UK study, examining GPs' predictions of which primary care tasks could be fully replaced by future technology and the anticipated timeframe for such changes. The researchers report that most GPs are very sceptical about the potential for future technology to perform primary care tasks, except for administrative tasks related to patient documentation. The subsequent qualitative analysis of the GP's free-text comments (Blease *et al.*, 2019) supports these findings, indicating that many GPs harbour doubts about the impact of emerging technologies on primary care, which the authors note diverges from the prevailing discourse and viewpoints of AI experts.

To summarise, the broader literature on healthcare students and professionals indicates a strong interest in AI, yet formal training remains limited. the wider literature considering healthcare students and professionals shows a strong interest in AI but lack formal training While AI is widely recognised for its potential to enhance diagnostics, improve efficiency and reduce errors, substantial knowledge gaps persist. Attitudes towards AI range from acceptance to scepticism, with concerns often centred on job security, ethics and regulatory oversight. Most view AI as a tool to support, rather than replace, human expertise. Key challenges include the need for transparency, robust regulation and data security. These findings reinforce the growing call to integrate AI education into undergraduate healthcare curricula to prepare future practitioners with essential competencies.

2.5 DISCUSSION

The scoping review indicates that pharmacists generally hold favourable perspectives on health technology and its potential to substantially enhance efficiency, accuracy and patient outcomes. Nevertheless, the literature suggests that successful implementation is dependent contingent upon several factors, including clear communication, comprehensive training, system interoperability, staff engagement and the mitigation of unintended consequences.

The research studies indicate that pharmacists perceive automation as a means to enhance operational efficiency (Afolabi and Oyeibisi, 2007b; James *et al.*, 2013b; Rodriguez-Gonzalez *et al.*, 2018; Ramachandram *et al.*, 2023) and to reduce medication errors (Van der Meer *et al.*, 2013; Rodriguez-Gonzalez *et al.*, 2018; Ramachandram *et al.*, 2023). Nonetheless, there are ongoing concerns among pharmacists regarding job security (Afolabi and Oyeibisi, 2007a) and the ability to adapt to new workflows and processes (James *et al.*, 2013b; Van der Meer *et al.*, 2013). The successful integration of automation into pharmacy operations necessitates staff training (Afolabi and Oyeibisi, 2007a; Rodriguez-Gonzalez *et al.*, 2018; Ramachandram *et al.*, 2023), effective communication (Crawford *et al.*, 1998; Van der Meer *et al.*, 2013) and the support and involvement of stakeholders during the transition process (James *et al.*, 2013b; Van der Meer *et al.*, 2013).

When considering research regarding the implementation of electronic prescribing, pharmacists report improvements in patient safety (Mehta and Onatade, 2008; Hogan-Murphy *et al.*, 2021) prescription accuracy (Mills, Weidmann, and Stewart, 2017; Grammatikopoulou *et al.*, 2024) and workflow efficiency (Hogan-Murphy *et al.*, 2021). Despite these advantages, challenges such as reduced face-to-face interaction (Mehta and Onatade, 2008), resistance from healthcare professionals (Mills, Weidmann, and Stewart, 2017) and concerns regarding system usability (Hogan-Murphy *et al.*, 2021), highlight the need for more comprehensive training and stakeholder engagement to ensure seamless adoption across pharmacy settings.

Similarly, the implementation of EHRs encounter challenges related to interoperability, data gaps and fragmented communication among healthcare providers (Mercer *et al.*, 2018; Tolley

et al., 2023). Although certain integrated EHR systems have been positively received by pharmacists (Kosari *et al.*, 2020), with their potential to enhance patient care, medication management, and interdisciplinary collaboration being noted, overcoming technical and administrative barriers remains a significant hurdle. The studies underscore the importance of effective communication across different healthcare sectors through shared EHRs to maximise their utility.

Clinical decision support (CDS) tools offer valuable assistance in medication management, including the identification of potential drug interactions and the optimisation of prescribing practices. However, the study by Hines *et al.* (2011) suggests that many pharmacists do not fully utilise these tools, often due to a lack of awareness or informatics training. Addressing these deficiencies through education and the development of user-friendly system designs could enhance the adoption and effectiveness of CDS in pharmacy practice.

Telemedicine has emerged as a promising avenue for expanding pharmacy services and increasing healthcare accessibility, particularly in remote and underserved areas. Although pharmacists generally hold positive attitudes toward telemedicine, barriers such as increased workload, lack of financial incentives and infrastructure limitations impede widespread implementation (Alghamdi *et al.*, 2022). Addressing these challenges through policy support, appropriate remuneration models and investment in digital infrastructure could enhance the role of telemedicine in pharmacy (Wathoni *et al.*, 2023).

The integration of AI within the field of pharmacy remains in its early stages. Nonetheless, pharmacists acknowledge the advantages of AI in enhancing operational efficiency (Alanzi, 2023; Jarab *et al.*, 2023), minimising medication errors (Syed and Al-Rawi, 2024) and supporting clinical decision-making (Jaber *et al.*, 2024). The existing literature indicates that pharmacists' concerns mirror those of other healthcare professionals and students, encompassing issues related to accuracy, privacy, cost and trust in AI-driven systems (Abu Hammour *et al.*, 2023; Jarab *et al.*, 2023; Smetana *et al.*, 2024). A consistent finding across studies in various healthcare disciplines is the imperative to provide comprehensive training and education to healthcare professionals. This is essential to enhance knowledge, address

resistance to change and optimise system usability, thereby maximising the potential of these technologies. Furthermore, ongoing evaluation, stakeholder engagement and policy support are critical to adapting these technologies to the evolving demands of healthcare (Gustafson *et al.*, 2024; Yousif *et al.*, 2024; Jairoun *et al.*, 2024).

Despite the potential advantages offered by digital technology, the studies highlight several prevalent concerns that should be addressed to enhance trust and acceptance among healthcare professionals and to facilitate more widespread adoption. These challenges encompass job security assurances, the establishment of effective regulatory frameworks, the development of interoperable systems with appropriate infrastructure and the enhancement of data security measures. Furthermore, the principles of accountability and transparency are essential for successful implementation and adoption.

Although there is an absence of direct studies soliciting pharmacists' predictions regarding the impact of technology on their future practice, the collective findings from the existing research indicate that pharmacists recognise the transformative potential of emerging technologies. They also acknowledge the necessity for enhanced training and educational opportunities to develop the requisite knowledge and skills, ensuring the continued relevance and effectiveness of the profession in an increasingly digital healthcare environment.

Overall, the findings of the scoping literature review reinforce the existence of a substantial research gap concerning pharmacists' perspectives on digital technology adoption, particularly within the UK and Wales. This confirms the need for the primary research undertaken in this study to capture expert opinions and forecast future trends.

2.6 RESEARCH AIMS AND OBJECTIVES

The literature review has addressed the initial objective of the study, namely the analysis and synthesis of published research that examines pharmacists' attitudes towards digital technology, automation and AI. The review indicates a paucity of research conducted within the UK that specifically examines pharmacists' perspectives on the impact of emerging technologies on pharmacy practice. Given pharmacists' expanding role in patient care and

healthcare delivery, as well as their expertise in medicines management and medication safety, it is imperative to explore their perspectives to ensure the successful integration of these technologies into pharmacy and healthcare, ultimately enhancing the quality of patient care and medication use.

This research project aims to address the gap in the literature, particularly within the unique context of the Welsh healthcare system. This will be achieved through four further research objectives:

- To assess pharmacists' opinions regarding the potential for digital technology, automation and AI to either replace or assist with pharmacy functions and duties by the year 2030.
- To ascertain pharmacists' priorities concerning future technological advancements in their practice in Wales.
- To critically explore pharmacists' views on the potential impact of digital technology, automation and AI on the pharmacy workforce in Wales.
- To critically examine the factors that pharmacists believe may facilitate or impede the implementation of digital technology, automation and AI in pharmacy practice in Wales.

The study seeks to provide valuable insights into the perceptions and interactions of this specific group of healthcare professionals with emerging technologies. The recruitment of a cohort of pharmacist leaders from diverse sectors of practice in Wales will facilitate a more comprehensive understanding of the digital landscape in Welsh healthcare. This understanding will inform future strategies for the implementation of digital solutions and AI in pharmacy practice across Wales.

2.7 STRENGTHS AND LIMITATIONS OF THE LITERATURE REVIEW

A key strength of this scoping review lies in its adherence to established methodological and reporting standards, namely the JBI guidance for scoping reviews (JBI, 2020) and the PRISMA-ScR framework (Tricco *et al.*, 2018), which enhance transparency and rigour. The development of the search strategy in collaboration with a senior health librarian further

strengthens the methodological robustness of the review. However, a notable limitation is the single-reviewer approach to reference screening and selection, which may have introduced potential bias and increased the risk of relevant studies being inadvertently excluded. To enhance reliability and reduce bias, future reviews would benefit from the involvement of multiple independent reviewers and the use of a consensus-based screening process.

2.8 CHAPTER SUMMARY

This chapter has synthesised the current evidence regarding pharmacists' perceptions of digital technologies, automation and AI, while highlighting significant gaps, particularly in relation to the Welsh healthcare context. The scoping review findings demonstrate a clear need for empirical research capturing expert pharmacy perspectives in this field, particularly considering pharmacists' predictions for future digital healthcare developments and proposed timescales for implementation.

In response to this gap, the following chapter details the research design and methodology employed to conduct a Delphi study, including participant recruitment, data collection procedures and the rationale for the chosen approach. By investigating their perspectives, the study seeks to provide insights into how this specific group of healthcare professionals perceives the impact of emerging technologies, their priorities for future advancements and their views on the facilitators and barriers to implementation within the pharmacy sector in Wales.

Chapter 3. Research Method

3.1 INTRODUCTION

This chapter outlines the study's research design and offers a rationale for using the Delphi technique to address the research questions. It details the project activities underpinning the methodology, including panel member recruitment, question development, survey design and piloting. The chapter describes the process of data collection, coding and thematic analysis during the initial qualitative phase. It also covers the construction of quantitative questions, methods of data analysis and process of providing feedback to participants.

3.2 RESEARCH AIMS AND OBJECTIVES

The first objective of the study was to critically synthesise the findings from a scoping review of existing research that examines pharmacists' attitudes towards digital technology, automation and AI. The review identified a paucity of studies focusing on pharmacists, particularly those from the UK and Europe, and noted the absence of research predicting the future utilisation of emerging technologies in pharmacy, timescales for their implementation, service priorities and potential impacts on the workforce. This Delphi study seeks to address this research gap. Critically exploring pharmacists' perspectives will offer valuable insights into potential barriers and facilitators for the implementation of digital solutions in pharmacy practice. Moreover, examining pharmacists' opinions will aid in identifying areas where targeted education and training could enhance their preparedness to adopt and integrate digital technology and AI-driven tools into their professional environment. Additionally, considering pharmacy within the distinctive Welsh context provides unique insights into rural healthcare and the influence of a small country on digital innovation.

To summarise, the four research objectives to be achieved through the systematic generation of expert consensus through Delphi are as follows:

- To assess pharmacists' opinions regarding the potential for digital technology, automation and AI to either replace or assist with pharmacy functions and duties by the year 2030.

- To ascertain pharmacists' priorities concerning future technological advancements in their practice in Wales.
- To critically explore pharmacists' views on the potential impact of digital technology, automation and AI on the pharmacy workforce in Wales.
- To critically examine the factors that pharmacists believe may facilitate or impede the implementation of digital technology, automation and AI in pharmacy practice in Wales.

3.3 RESEARCH PARADIGM

It is widely acknowledged that researchers possess diverse experiences, values and perspectives, which influence how they frame research questions and conduct research. These factors include assumptions about the reality of the work (ontology), nature of knowledge (epistemology) and methods of knowledge acquisition (methodology) (Schwandt, 2001; Bowling, 2014; Gray, 2018). This fundamental belief system and theoretical framework, from which the researcher interprets the world and designs their study, constitutes their research philosophy or paradigm (Clark *et al.*, 2021).

In scientific research, positivism has been the predominant underlying philosophical paradigm. This approach applies experimental research principles to collect, measure and analyse data to establish "scientific truth" (Bowling, 2014, p. 132). Positivists assert that truth can be determined by controlling variables and testing for cause-and-effect relationships, with quantitative methods prevalent (Moule, 2018). However, Gray (2018) suggests contemporary researchers are often cautious about fully embracing positivistic positions, preferring to determine the probability of their findings being correct.

Interpretivism, also known as constructivism, challenges the positivist perspective by arguing that multiple socially constructed realities exist, shaped by individuals' experiences and interpretations (Crotty, 1998). Miles and Huberman (1994, p. 8) assert that interpretivists believe researchers are "no more detached from their objects of study than their informants" and bring their own convictions to research as members of a particular culture at a specific

moment in time. As individuals' experiences change over time, so can the meanings they attribute to a situation, making it a constantly evolving process (Gray, 2018).

Another contrasting paradigm is critical theory, where researchers seek to understand reality while engaging in the research, aiming to confront privilege and power in society, engender change and challenge the status quo (Crotty, 1998). Crotty asserts researchers in this paradigm examine "the way discourse produces and reproduces social domination" or power abuse by one group over another (Crotty, 1998, p. 113). Denzin and Lincoln (2017) state academics in this paradigm are committed to action and McNamara (2009, quoted in Gray, 2018, p. 29) suggests that highlighting injustices benefits both researchers and participants. In healthcare, Churchman and Doherty (2010) highlight research showing nurses often refrain from challenging doctors due to occupational hierarchy, medical dominance and historical gender inequality between the professions.

In the past pharmacy practice research was often considered scientific, with the International Pharmaceutical Federation Pharmacy Practice Special Interest Group (FIP PPR-SIG) defining it as a "scientific discipline that studies the different aspects of the practice of pharmacy and its impact on health care systems, medicine use and patient care" (Garcia-Cardenas *et al.*, 2020, p. 1602). However, as the scope of pharmacy practice has expanded to include person-centered care, research now encompasses the clinical, behavioural, economic, innovative and humanistic implications (Fernandez-Llimos *et al.*, 2023). The previous dominance of quantitative research methods has been challenged due to concerns about reliability in real-world pharmacy practice. As a result, many researchers are embracing different theoretical perspectives and preferring the richness of information from qualitative studies (Tonna and Edwards, 2013). Gallego and Nørgaard (2018) concur, stating that increased use of qualitative methodologies to understand, explain, discover and explore patients' and healthcare practitioners' perceptions will improve healthcare practice.

3.3.1 Delphi Research Paradigm

There is debate on the Delphi technique's underlying philosophical paradigms (Keeney, Hasson and McKenna, 2011; Jaam *et al.*, 2022). Although the statistical analysis of

quantitative data suggests its placement in a scientific positivist paradigm, the technique incorporates qualitative methods, and many studies aim to provide insight into the significance of events for individuals and the broader social context (Bowling, 2014). Keeney, Hasson and McKenna (2011, p. 21) propose that Delphi research is based on the constructed reality of the expert panel members and “does not fit into the reliability and validity criteria, as defined within the traditional positivist paradigm”.

The technique can be considered interpretivist as it relies on participants’ valued opinions of based on their understanding of the world (Cresswell and Poth, 2018). It employs qualitative methods to understand participants’ perspectives and experiences in their natural setting, describing reality through collaboration and knowledge sharing to achieve consensus (Cohen, Mannion and Morrison, 2007; Skulmoski *et al.* 2007). Humphrey-Murto *et al.* (2017) suggest the mixed or multi-method approach classifies it as pragmatism. A compromising stance taken by Critcher and Gladstone (1998) is that, due to the generation of quantitative through qualitative approaches, Delphi has a hybrid epistemology propose Delphi has a hybrid epistemology due to generating quantitative through qualitative approaches. Day and Bobeva (2004, p. 5) echo this, claiming Delphi overlaps “positivist/ quantitative” and “interpretative/ qualitative” ideals.

3.4 THE DELPHI TECHNIQUE

The Delphi technique is an ideal method to use to develop consensus opinion among knowledge leaders, where there is incomplete knowledge about a topic (Nasa, Jain and Juneja, 2021) or little raw data (Hasson, Keeney and McKenna, 2000). The purpose of the process simply defined by Crabtree and Miller is “to achieve convergence of opinion from topic experts about a particular topic” (Crabtree and Miller, 2023, p. 113).

This structured research method values multiple viewpoints, based on the premise that “pooled intelligence enhances individual judgement” (de Villiers, de Villiers and Kent, 2005, p. 639). It is increasingly used in health service research to congregate expert opinion through anonymous questionnaires across multiple rounds (Jaam *et al.*, 2022). Gordon and Pease propose that consensus is not necessarily the only objective or measure of success, but rather

the value lies in the "ideas it generates" and the reasoning behind responses (Gordon and Pease, 2005, p. 322).

3.4.1 Background and Applications of Delphi

The Delphi technique was originally developed in the 1950s by Dalkey and Helmer of the Rand Corporation to inform US military defence priorities (Okoli and Pawlawski, 2004). Named after the ancient Greek Oracle of Delphi, this data collection method has been used across various fields and research disciplines (de Villiers, de Villiers and Kent, 2005; Okoli and Pawlawski, 2004). It has been employed to study topics ranging from mitigating fake news impact on commercial brands (Flostrand, Pitt and Kietzmann, 2020) to developing consensus prescribing guidelines for dementia patients (Page *et al.*, 2015).

The increasing popularity of the Delphi method in healthcare research has been seen in the field of pharmacy. A 2021 pharmacy review paper critically appraised pharmacy practice studies using the Delphi technique, providing a repository of best-practice examples and a useful guide for pharmacy researchers (Jaam *et al.*, 2021). Within pharmacy in the UK, the technique has been applied to develop consensus responses for various research questions, including evaluating resources to reduce medication incidents in critical care pharmacy (Bourne, Shulman and Jennings, 2018), agreeing on information for GP-based pharmacists to record on clinical computer systems (Karampatakis *et al.*, 2019) and reaching consensus on high-risk preventable prescribing errors for developing a simulation tool to evaluate electronic prescribing systems' safety (Heed *et al.*, 2022).

As a forecasting tool, it is particularly useful for predicting technological developments. In healthcare, Blease *et al.* (2020) researched expert health informaticians' predictions of AI and machine learning's impact on US primary care general medical practice in the next decade. The researchers justified using the Delphi method as it suits developing "consensus views related to new lines of inquiry" and the views of health informaticians about AI's impact had not been explored before (Blease *et al.*, 2020, p. 2).

3.4.2 Advantages of Delphi

A key strength of the Delphi method is the anonymity of panel members. This allows free expression of opinions without undue social or professional pressure to conform and removes the influence of individuals who can monopolise discussions in a face-to-face group setting (Jaam *et al.*, 2022).

For this study, the term "quasi-anonymity" used by Hasson, Keeney and McKenna (2000) is more appropriate. The participants are known to each other as senior pharmacists working across different sectors in Wales, collaborating through national committees, professional groups and commissioning services. Although they know who else has been asked for their opinion, they cannot attribute any view to an individual. This negates disadvantageous power relationships and encourages ideas from all participants. It could also encourage panellists to participate if they know they are invited as experts in the field in Wales, as "members of an exclusive club" (Keeney, Hasson and McKenna, 2011, p. 10).

Hasson, Keeney and McKenna (2000, p. 1008) describe the method as a "group facilitation technique, which is an iterative multistage process, designed to transform opinion into group consensus." Gordon and Pease (2005) consider an advantage of this iterative process is that it allows respondents to alter their opinions during the study without fear of judgement from peers. This aligns with the nature of this study using pharmacy peers in Wales, who may feel pressured to conform with others' views in a live group discussion.

This study uses an electronic Delphi method, conducted via email or online forms (Avery *et al.*, 2005; Schwendicke *et al.*, 2021). This approach employs electronic survey tools like SurveyMonkey and Qualtrics, which expedite the research process and reduce turn-around time between rounds, enhancing participant engagement (McPherson, Reese and Wendler, 2018). These programmes provide templates to create and distribute questionnaires, send reminders and enable rapid data collation and analysis between Delphi rounds. The online questionnaire gathers opinions from geographically dispersed participants from different organisations, negating the need for physical meetings and avoiding "direct confrontation of experts" (Okoli and Pawlowski, 2004, p. 2). This is pragmatic as participants are busy

professionals; the ability to answer questions online at their convenience offers flexibility and encourages study completion (de Villiers, de Villiers and Kent, 2005). The functionality for online data collection is practical for a practitioner-researcher. Additionally, an entirely online Delphi study reduces environmental impact by avoiding carbon emissions from paper-based questionnaires or unnecessary travel to meet expert panellists in person.

3.4.3 Limitations of Delphi

Although the Delphi method is well-suited to achieving consensus on complex issues, there are disadvantages and limitations to consider. According to de Villiers, de Villiers and Kent (2005), a major limitation is that it is time-consuming and involves multiple rounds of iterative exchanges. McKnight *et al.* (1991) states that it takes an average of 45 days for the full document exchanges to be completed. However, electronic communication and online survey tools should significantly reduce study time. Some researchers view the Delphi method as "administratively complex, highly labour intensive and expensive" and it requires ongoing commitment from researchers and participants (Keeney, Hasson and McKenna, 2011, p. 29). Nasa, Jain and Juneja (2021) caution researchers to be mindful of the low initial acceptance rate among experts and high attrition rate throughout the multiple-round process and to consider this during the invitation stage.

Gray advises that online surveys have a lower response rate than other methods and researchers should employ strategies to increase participation and ongoing engagement. These include gaining interest through informal introductions, sending personally addressed emails, targeting "organisational gatekeepers" to identify suitable individuals and following up with non-responders (Gray, 2018, p. 255). Due to the qualitative nature of the initial round, the data collected through open-ended questions is limited by participants' willingness to provide it, as these answers require "more thought and are more taxing for respondents" (Bowling, 2014, p. 295). There is also concern about the content of quantitative rounds. In a systematic review of healthcare e-Delphi studies for core outcome set development, Gargon *et al.* (2019) found a significant association between the number of items the panel votes on and the response rate, with more items resulting in lower response rates. Researcher bias

and preconceptions are another limitation, particularly during analysis, although this is discussed in more detail in the following chapter.

3.4.4 Other Techniques to Gather Expert Opinions

The perspectives and beliefs of the expert pharmacists could have been explored through various qualitative methodologies. Interviews, defined as verbal interactions between one or more researchers for the purpose of collecting valid and reliable data to address a specific research question (Parahoo, 2006), are particularly effective for gathering rich, in-depth data when the research objective is primarily exploratory (Gray, 2018). In-person interviews enable researchers to observe non-verbal cues, such as facial expressions and body language, which add depth to verbal responses and facilitate the development and clarification of responses (Bell, 2005). This method allows researchers to build trust and engagement, and the controlled setting enhances data accuracy by minimizing distractions and misinterpretations (Gray, 2018). However, face-to-face interviews can be time-consuming and costly to conduct, and they present validity concerns due to potential interviewer bias, where tone and phrasing may unconsciously influence responses, and social desirability bias, where participants may provide answers they believe are more acceptable to the interviewer (Parahoo, 2006). In this study, the majority of the pharmacist experts are known to the researcher in a professional context, which might either positively motivate them to divulge more information or discourage them from revealing sensitive details or expressing negative views about their work experiences in Wales.

Focus groups, which assemble a selected group of individuals to offer a range of perspectives, can be a more economical method of interviewing multiple participants (Gray, 2018). They provide a broader understanding of the research topic with the opportunity for immediate comparison of perceptions and experiences, although transcribing multiple viewpoints can be challenging. The cooperation and active participation of individuals are essential, and respondents may have concerns about sharing unpopular or confidential information. Researchers require excellent group facilitation skills to ensure all participants are heard and to prevent dominant personalities (or senior staff) from monopolising discussions, which could hinder less assertive members from speaking (Bell, 2005).

The Nominal Group Technique (NGT) has been utilised in health service research for the purpose of developing expert views and guidelines. Participants are initially required to reflect on and record their thoughts on the topic in question. The group is then brought together with a facilitator, and the individual results are presented for discussion. The differences between the individual opinions are then deliberated upon, allowing for the possibility of revising or re-ranking their views in light of the group's input (Bowling, 2014). McMillan, King, and Tully (2016) argue that this highly structured group technique empowers participants by providing them with an opportunity to have their voices heard and their opinions considered by other members. In contrast to the Delphi method, NGT is a more time efficient approach for achieving consensus. However, it is still necessary to bring the expert panel together and to have a skilled facilitator present in order to mitigate the influence of dominant individuals, which can adversely impact the outcome and undermine the validity of the consensus, as discussed previously (Jaam *et al.*, 2022). Newham *et al.* (2023) have adapted the technique from the traditional face-to-face to a virtual format in their study to develop outcome measures to assess the impact of clinical pharmacists in general practice. They welcome the increased and normalised use of online meetings and video conferencing capabilities across healthcare, which can now bring experts from different geographical locations together to join a virtual NGT panel. This technique was initially considered for this study as Microsoft Teams software was rapidly rolled out across NHS Wales at the start of the COVID-19 pandemic. This could have facilitated a similar virtual adaptation. However, it was not as convenient for the experts as Delphi, and the challenges of scheduling panel meetings into busy pharmacy professionals' calendars may have reduced participation and ultimately the range of opinions gathered.

The World Café (WC) methodology has been used in organisational change and to support citizen participation (Löhr, Weinhardt and Sieber, 2020). It has gained popularity in health and social care as a methodological approach to collecting qualitative data, and pharmacy researchers have used it in a number of studies to develop consensus (Maskrey and Underhill, 2014; Kavanagh *et al.*, 2020; Recchia *et al.*, 2022). WC also brings experts together; however, discussions are held in smaller groups to consider specific issues at different tables.

Conversations are facilitated and key points of agreement recorded. Individuals rotate around the tables regularly to ensure that they contribute to all topics, engage in constructive dialogue and build relationships in the group (Fouche and Light, 2011). The final data generated is enriched through the diversity and inclusivity of the discussions (Recchia *et al.*, 2022). This was considered as a method for this study due to the researcher's previous experience of the technique, however the constraints of expert capacity, venue availability and requirement for multiple facilitators were limiting factors.

3.4.5 Justification for the Use of the Delphi Method

In their guidance to pharmacy educators on how to employ Delphi to aid in decision making and build consensus, Olsen *et al.* (2021) observed that many researchers fail to provide a rationale for utilising this method or to fully describe and justify their methodological steps. For this study, any of the other techniques described previously could have been used to gather expert views however Delphi offers several advantages for this study. It offers anonymity to pharmacist experts, allowing free expression of individual views (Jaam *et al.*, 2022). The method reduces dominance bias and groupthink, giving equal weight to all expert opinions (Keeney and McKenna, 2000). The iterative process enhances reliability by enabling pharmacists to refine their perspectives over multiple rounds. Delphi's structured feedback improves the quality of insights and reduces hasty conclusions. It is logistically more efficient than individual interviews and more flexible than focus groups, as the busy pharmacist can respond at their convenience (de Villiers, de Villiers and Kent, 2005). The technique offers greater methodological rigor and objectivity through its structured process, often including quantitative assessments like ranking or rating scales. This facilitates systematic analysis of expert opinions, ensuring findings are supported by measurable data rather than solely qualitative narratives (Keeney, Hasson and McKenna, 2011).

Alternatively, a conventional survey of pharmacists in Wales could have gathered information on their perspectives on digital technology, automation and AI. However, the Delphi method was deemed more appropriate for several reasons. Firstly, there was limited research on the subject, and the technique is ideal for systematically building consensus through its iterative nature (Nasa, Jain and Juneja, 2021). The initial qualitative round of open-ended questions

allows for free expression of opinions and mitigates potential bias introduced by the researcher-practitioner in constructing statements for subsequent quantitative survey rounds (Keeney, Hasson and McKenna, 2011). Due to the expert knowledge participants contribute, the size of the Delphi panel can be modest, while providing a rich dataset for analysis within the available timeframe (Okoli and Pawlowski, 2004; Jaam *et al.*, 2022). Furthermore, the investigator's professional standing enabled assembling a panel of knowledgeable experts from diverse Pharmacy sectors in Wales to address the research questions. While this panel selection was convenient, it was also "deliberate and purposive" to ensure the requisite expertise necessary to address the research question, as recommended by Olsen *et al.* (2021, p. 1382).

3.4.6 Methodological Considerations of Delphi

As the Delphi technique overlaps both positivist and interpretative research paradigms, establishing methodological rigour poses a challenge (Keeney, Hasson and McKenna, 2011). However, as Altheide and Johnson (1994) caution, to enhance the credibility of findings from Delphi studies, demonstrating reliability and validity (terms typically associated with positivist qualitative methods) may not be as straightforward as with other methods.

Reliability can be thought of as the stability and consistency of the results when the method is applied repeatedly under constant conditions (Hasson, Keeney and McKenna, 2000). Some researchers have observed that Delphi studies exhibit long-range forecasting accuracy and produce similar outcomes when retested with panels many years later (Ono and Wedemeyer, 1994). However, in this study, time constraints preclude from repeating the surveys with the same panel at a later date or comparing findings from different panels to assess consistency. Nevertheless, these comparisons could be conducted in future research. Additionally, other researchers have advocated for enhancing the reliability of group consensus by increasing panel size, ensuring anonymity and mitigating group bias (Keeney, Hasson and McKenna, 2011).

Validity refers to the accuracy of a method in achieving its intended objectives and the usefulness of the inferences derived from the collected data (Creswell, 2009). Researchers

propose that Delphi provides content and face validity through several mechanisms. These include the premise that several people are less likely to arrive at an erroneous decision than a single individual; the process involves the opinions of experts from the field; and the inclusion of the qualitative round enables participants to devise the statements and test them throughout subsequent rounds (Cross, 1999; Hasson, Keeney and McKenna, 2000; Morgan *et al.*, 2007). Keeney, Hasson and McKenna (2011) suggest that researchers should consider potential threats to the validity of their study, including questions regarding the generalisability of expert opinions to the broader population and concerns about potential researcher bias.

Due to the qualitative methods used in this technique, some researchers have suggested that employing validity and reliability measures are not appropriate, as they were primarily designed for more positivistic research methodologies (Keeney, Hasson and McKenna, 2001). Furthermore, alternative criteria such as trustworthiness, credibility, stability, neutrality or transferability have been proposed to be more applicable when evaluating the Delphi method's effectiveness (Day and Bobeva, 2005; Cornick, 2006; Hasson and Keeney, 2011).

3.5 THE EXPERT PANEL

The initial decision on the inherent characteristics that constitute expertise in relation to the research question is essential when identifying a panel. Experts are viewed differently by various scholars. McKenna (1994) adopts a straightforward approach, considering experts as informed individuals. In contrast, de Villiers, de Villiers and Kent offer a more comprehensive definition, describing a suitable expert as "someone who possesses the relevant knowledge and experience and whose opinions are respected by fellow workers in their field" (2005, p. 640).

As in most Delphi studies, the selection of the experts in this research followed a non-probability sampling method (Jaam *et al.*, 2021). This approach was deemed more appropriate than random sampling, given that the characteristics of the experts with regard to interest and knowledge would not be uniformly distributed in the population (Crabtree and

Miller, 2023). Instead, purposive or criterion sampling techniques were employed to provide a diverse range of perspectives for the study (Hasson, Keeney and McKenna, 2000).

For this study, potential participants were pharmacists with expertise in different areas of practice across Wales (e.g., community, hospital, academia, government and the pharmaceutical industry). To ensure that participants had the necessary expertise to provide rich data for the investigation, they were required to have sufficient experience in their area of pharmacy practice. Consequently, the term expert was determined using the following criteria:

Professional status: All participants were qualified pharmacists who were registered with the General Pharmaceutical Council. Other pharmacy registrants, such as pharmacy technicians, and non-pharmacists working in pharmacy fields (e.g., Dean of the School of Pharmacy in Bangor University, scientists working in the pharmaceutical industry) were excluded from the study.

Experience in pharmacy: All participants had at least five years of experience working in pharmacy.

The potential pharmacy experts were identified through their membership of the Welsh Pharmaceutical Committee (WPC) and the wider network of senior pharmacists within NHS Wales. As described by Gray (2008, p. 220) and Parahoo (2006, p. 270) a “snowballing strategy” was utilised to enlist potential participants with an interest in the area who had been suggested by the initial group and other panellists within specific areas of practice that were not represented.

3.5.1 Participant Information Recruitment and Consent

Recruiting experts to the research panel was a crucial stage of the study. Due to time constraints, it was not feasible to personally contact all potential panellists before sending the initial invite and first survey round. This aspect represented a limitation, as previous research and guidance from McKenna (1994) and Hasson, Keeney and McKenna (2000) indicate that direct contact can enhance response quantity and maintain expert commitment throughout Delphi rounds. The inability to discuss the research with all potential participants prior to administering the first round resulted in the issues discussed above, as some contacts

were ineligible, one expert was absent from work and one email address appeared obsolete. This negatively impacted the research timeline, as unnecessary researcher resource was used to generate individual survey links, write emails and follow up with non-responders.

Personalised introductory emails were sent to potential participants, with the initial greeting tailored individually, based on prior familiarity with the study or previous interactions with the researcher (refer to Appendices c, d and e). The emails included brief details about the study to pique interest, alongside a unique link to access the initial phase of the web-based questionnaire. Potential panel members could reach out to the researcher for additional details or to discuss the study further. Engaging prospective panellists through this first interaction was vital for the project's success, as no incentives were offered to complete the survey.

The participant information sheet available in Appendix f describes the aims of the research and the features of a Delphi study. The connection between the research and the pharmacy profession's 2030 goals of 'Harnessing Innovation and Technology' (Welsh Pharmaceutical Committee, 2019) was highlighted to capture the interest of potential participants.

As recommended by Grisham (2008), the necessary time commitment for panellists and anticipated number of rounds were communicated to ensure respect for their time and full disclosure on initial contact. This was important to highlight at the recruitment stage to protect against panel attrition later in the Delphi study. Information was provided about ensuring confidentiality and anonymity of experts' responses, with assurances on data management, storage and dissemination of research findings. The participant information sheet was also used to obtain informed consent from participants at the outset and continued consent was implied through submission and completion of all questionnaires. Experts were informed that participation was voluntary, and they could withdraw at any point without explanation or prejudice. They were advised that if they chose to withdraw, they could request removal of their data from the study. However, none of the participants made such a request. To maintain consistency and brand recognition, the University of Wales Trinity

Saint David (UWTSD) logo was included in the introductory email, participant information sheet and survey template for every questionnaire.

3.5.2 Panel Size

There is no standard method to determine the ideal panel size for a Delphi study. While a larger panel size may enhance the reliability of the data gathered from the responses, Hasson, Keeney, and McKenna (2000) suggest that an increased sample size could present challenges to the researcher in terms of data analysis capacity and data management. Gargon *et al.* (2019) found that studies with smaller panel sizes achieved significantly higher response rates in the second round, although this may be attributed to the research team's ability to personally contact potential participants.

A meta-analysis of systematic reviews of Delphi techniques in health sciences found that the number of experts recruited to panels varied greatly from three to 731. However, the average number was usually “low to medium double-digit range” (Niederberger and Spranger, 2020, p. 4). In Pharmacy research, McMillan, King, and Tully (2016) suggest that 15 experts might be sufficient for a Delphi panel, as increasing numbers could lead to diminishing returns. In 2021, Olsen *et al.* considered the optimal number for panellists in pharmacy studies, maintaining that 10 to 15 panel members were typical, although initial recruitment should take into account the lack of participation and subsequent panel attrition. Published pharmacy studies using the Delphi technique support this finding. For example, Watson *et al.*'s (2019) Delphi study of pharmacists' roles in the field of disaster management selected 24 experts to participate, with 15 concluding the study. Pouliot *et al.* (2018) invited 50 international participants to reach consensus on the 'definition of medication literacy', where 28 consented to participate and 11 completed all the rounds.

Taking into account the potential for a lower response rate and attrition throughout the rounds, the study intended to recruit approximately 30 experts from various sectors of pharmacy in Wales, with a minimum sample size target of 20 and no upper limit. This moderately-sized sample size allowed for a manageable dataset of results to be examined and provided sufficient information to make reliable inferences. Out of the 61 initial emails

dispatched, 38 participated in the first round, 33 finished Round two and 32 completed Round Three. This exceeded the desired target of 30 expert panel members.

3.5.3 Panel Survey Tool

The selection of an appropriate online survey tool is crucial for questionnaire design, response tracking and data collection (Gray, 2018). Qualtrics XM survey platform was chosen due to its user-friendly interface and complimentary university access. The software offers various question types for survey development, including multiple choice, open-ended, and matrix question templates. The platform generates unique, trackable survey links for each participant, which are distributed via personally addressed emails from the researcher, ensuring total anonymity from other participants. Additionally, the software enables real-time data collection from the participants and automatic transfer to other data analysis packages, eliminating the need for manual manipulation of the data (Qualtrics, 2024).

3.6 THE STUDY DESIGN

The number of rounds in a Delphi study can vary, with some healthcare studies using 14 rounds to gain consensus (Niederberger and Spranger, 2020). The original Delphi employed four rounds, but later studies often used two or three rounds to reduce panel attrition and increase response rates (Keeney, Hasson and McKenna, 2011; McMillan, King, and Tully, 2016).

The first round of a classical Delphi starts with open-ended questions, allowing researchers to gather rich qualitative data and provide "panel members freedom in their responses" (Keeney, Hasson and McKenna, 2011, p. 197). This data is used to develop questionnaires for future quantitative rounds, where measurement scales determine participants' agreement with statements and priorities.

After the initial quantitative round, a summary of the collated responses can be shared with the panel members prior to the next round of questions, through a process of controlled feedback (Hasson, Keeney and McKenna (2000). According to Nasa, Jain and Juneja (2021),

this feedback is considered ‘controlled’ because the investigator decides on the specific information to be provided to the participants.

Following the recommendations of Trevelyan and Robinson (2015), this Delphi study was limited to three rounds to maintain engagement and interest about the topic throughout the study, avoid participant fatigue and minimise the study burden on busy professionals. The diagram (Figure 2) below presents a summary of the study's design.



Figure 2. Flow chart of research study process.

A prompt turnaround between rounds is vital to minimise attrition and maintain high levels of enthusiasm and participation, as recommended by Skulmoski *et al.* (2007) and Gargon *et al.* (2019). The timeframe between data collection, analysis and the release of subsequent rounds is of utmost importance. The introductory email specified that the three rounds would be distributed by the end of December 2023, providing a deadline for the researcher to work towards and plan backwards from, establishing target dates for survey circulation and turnaround times between rounds. The timeline followed is shown in Figure 3 below.

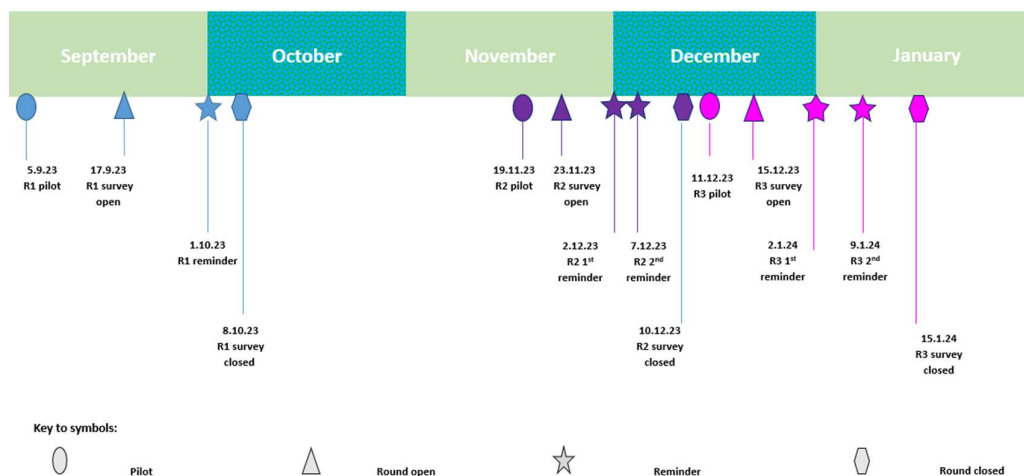


Figure 3. Timeline for three round Delphi study from September 2023- January 2024.

The researcher's project management skills, gained through complex workplace projects, were leveraged to meet deadlines. Study leave was booked in advance to accommodate predicted periods of high workload within short timeframes.

3.7 ROUND ONE

As this study followed a "traditional Delphi" approach, the first qualitative questionnaire gathered opinions and generated ideas from the expert panel to aid in composing questions for subsequent rounds (Jaam *et al.*, 2021, p.2238). The open-ended questions on research themes were broad, asking participants to provide views in free-text responses. This approach allowed participants to articulate thoughts without constraint (Keeney, Hasson and McKenna, 2011).

3.7.1 Demographic Questions

The first-round questionnaire consisted of two sections. The first section included five demographic questions with multiple-choice responses. During the pilot phase, the number of questions was minimised to the essential ones. The final survey employed multiple-choice questions as a means of eligibility verification, ensuring that panel members were employed in Wales and possessed the requisite minimum years of experience.

Additionally, their specific area of pharmacy expertise was documented to ensure representation across various sectors of practice. Data regarding age range and sex was also collected, facilitating the potential exploration of correlations between these variables and opinions on digital technology and AI in subsequent analyses. This information is presented in Table 5 below.

Table 5. Delphi Round One demographic questions.

Multiple choice questions								
Q1 - Where do you currently work or practice?								
Response	Wales	England	Rest of UK	Other				
Q2- How many years' experience do you have in Pharmacy?								
Response	0-5	>5-10	>10-20	>20				
Q3- What is your area of expertise in Pharmacy?								
Response	Community Pharmacy	Hospital/ Acute Pharmacy	Primary care Pharmacy	General Practice	Academia/ Education	Government	Professional body/ Regulation	Other
Q4- Age (years)								
Response	25 or younger	>25-35	>35-45	>45-55	>55	Rather not say		
Q5- Sex								
Response	Male	Female	Other	Rather not say				

3.7.2 Developing the Qualitative Questions

As a practitioner-researcher, it was important to be aware of potential bias or internal "worldview" influencing question design (Crabtree and Miller, 2023, p. 333). Some modified Delphi studies omit the initial qualitative round and present predetermined statements to save time (Keeney, Hasson and McKenna, 2011). However, for this study it was felt that

compiling statements for a quantitative round could increase researcher bias and depth of the data that could be gathered from experts.

In order to produce the initial round of questions, the original research objectives were taken into account, along with the research examined during the literature review. Fortunately, many studies investigating other health professionals' attitudes toward technology have included the questionnaires or interview guides employed in their research within their appendices (Pinto do Santos *et al.*, 2019; Blease *et al.*, 2020; Park, Paul, and Siegel, 2021; Buck *et al.*, 2022; Blease *et al.*, 2023). A list of possible questions with varying phrasing was prepared for the initial discussion with the research supervisors (Appendix g). The questions were grouped, restructured and refined through supervisory sessions. Further editing and rephrasing of a few questions were carried out at the pilot stage, taking into account the comments and advice from the pilot participants.

The initial qualitative round questions were broad to gather expert opinions on research themes, avoiding vagueness that could lead to unrelated or ambiguous answers difficult to analyse. Keeney, Hasson, and McKenna (2011) state that poorly formulated questions could compromise data reliability and validity.

Table 6. Delphi Round One- Questions 6 to 8.

Open questions
Q6 - By 2030, what tasks and roles in Pharmacy do you think could be ASSISTED by digital technology and artificial intelligence?
Q7 - By 2030, what tasks and roles in Pharmacy do you think could be FULLY REPLACED by digital technology and artificial intelligence?
Q8- By 2050, what other applications do you foresee for digital technology and artificial intelligence in Pharmacy?

In the first set, the open questions were based on Blease *et al.*'s research on GPs' perceptions of future technology replacing their work in the UK and US (Blease *et al.*, 2018 and 2020).

Blease *et al.*'s (2023) later study of Irish medical students distinguished between technology 'working alongside' or 'fully replacing' GPs. This approach was adopted to encourage positive responses and avoid alarming participants about job loss. The terms digital technology and AI were also not differentiated at this stage or fully defined for the participants, in order to provide an opportunity for personal interpretation of the questions and unbiased opinions from the respondents. Questions 6 and 7 included the 2030 timeframe for participants to consider potential developments in pharmacy in the near future. The choice of the year 2030 is similar to the 2029 date selected by the study conducted in the United States by Blease *et al.* (2020) that examined the impact of AI and ML on primary healthcare. The study proposes that asking professionals to forecast the impact of AI/ML on healthcare in the 'near-future' can improve the credibility of responses and distinguish between hype and hope. The researchers recommend the need for accurate short-term predictions to make informed decisions about resource allocation and ensure the adequacy of medical education and training for future professionals.

Originally, the questions asked participants to predict what would happen 'in the next ten years' as an interval to measure the near future. However, at the time of the composing the questions, the year 2030 was prominently featured by the Welsh pharmacy profession's own vision for the future titled 'Pharmacy: Delivering a Healthier Wales' (or PDaHW) (Welsh Pharmaceutical Committee, 2019). The strategic plan details the profession's development and contribution to patient care until 2030, based on the principles and recommendations of the Welsh Government's strategy for health and social care, 'A Healthier Wales' (Welsh Government, 2018). There are several strategic goals for 2030 related to technology and innovation. The year 2030 is also referred to as an important target set by Health Education and Improvement Wales (2023) in their 'Strategic Pharmacy Workforce Plan' by which time the pharmacy profession would be a digitally ready workforce. The plan states:

'By 2030, the digital capabilities of the pharmacy workforce will be well developed and widespread to help us deliver the best possible care for people using the latest advances in technology key findings to date'

Therefore, the year 2030 was included in the questions (with a link to the PDaHW strategy in the participant information) to ensure the topic was aligned with the participants' interests (as recommended by Olsen *et al.*, 2021) and motivating them to provide thoughtful, detailed responses. The reference to the PDaHW strategy also ensured support for the research from senior colleagues in the Royal Pharmaceutical Society in Wales who were actively promoting the strategy through various forums.

The purpose of Question 8 in Round One was to investigate the profession's long-term predictions regarding the potential of technology in pharmacy. Participants were asked to anticipate the impact of technology on pharmacy, similar to the first study conducted by the RAND corporation using the Delphi technique to forecast the impact of technology on warfare (Keeney, Hasson and McKenna, 2011). The arbitrary date of 2050 was chosen to allow participants to engage in some blue-sky thinking of the art of the possible, without any of the current constraints they might foresee limiting short-term implementation by 2030. The wording of the question was adapted from a similar question used in a study by Pinto do Santos *et al.* (2019) to survey European medical students.

The second page of the qualitative questions looked at more specific themes related to the profession and the situation in Wales. These are shown overleaf in Table 7.

Table 7. Delphi Round One- Questions 9 to 12.

Open questions
Q9- To what extent do you think Pharmacy in Wales is prepared to be able to utilise and harness digital technology and artificial intelligence?
Q10 – What concerns or risks for Pharmacy do you have with the use of digital technology and artificial intelligence?
Q11- What advantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?
Q12- What disadvantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?
Please feel to add any other comments on the survey topic below.

Question 9 aimed to determine whether experts believed the pharmacy profession was equipped to handle their future predictions. It was designed to capture any necessary preparations for future strategic planning, without leading participants to suggest further training or education needs. Question 10, adapted from Buck *et al.*'s (2022) interview guide, sought to understand attitudes towards AI involvement in medical diagnoses. An earlier draft of this question specifically asked whether the experts had any concerns about the future of the pharmacy workforce, but this was rewritten to reduce any implied researcher bias and capture broader risks or concerns.

The final questions asked participants to consider pros and cons of practicing pharmacy in Wales regarding future technological implementations. These questions were tailored to the expert participants to increase response rates and gather rich data. The survey concluded with an opportunity for additional comments, ensuring participants could raise important views potentially omitted in the initial questions.

3.7.3 Construct of the Survey for the First Round

The Round One survey was limited to three pages, following Gillham's (2007, quoted in Gray, 2018, p. 343) recommendation to maximise response rates. Novakowski and Wellar (2008, p. 1497) support this, emphasising the need to "minimise the size and complexity of the questionnaire" to maintain participant interest and response quality. While Fowler (2014) notes that respondents appreciate open-ended questions, caution is needed to avoid survey fatigue. Braun *et al.* (2021) found that longer qualitative surveys may lead to shorter, less detailed responses as a result of participant disengagement.

After testing various layouts, the final four open questions were grouped on a single page at the end, allowing respondents to visualise the survey's conclusion and potentially improving completion rates. Screenshots of the Qualtrics Round One survey are available in Appendix h.

3.7.4 Piloting Stage

Piloting the data collection tool is a critical element of a good Delphi research design and is used to determine whether adjustments to the survey instrument are required (Bowling, 2014, p. 150). In this study the trial run, as described by Novakowski and Wellar (2008), was undertaken by a small number of pharmacists and researchers (n=5) who were not part of the Delphi expert panel, in order to avoid potential contamination of the data (van Teijlingen and Hundley, 2002).

To ensure the content and face validity of the survey, pilot participants were instructed to complete the online survey as if they were members of the expert panel (Keeney, Hasson and McKenna, 2011). Participants provided feedback on layout, ease of use, content and wording. There was 100% response rate, and they indicated overall satisfaction with the survey's simplicity, navigation and length. Minor grammatical errors were corrected, and the participant information sheet was incorporated into the survey based on suggestions. Despite successful piloting, an unexpected issue arose during the main study when the survey expired prematurely, highlighting the importance of thorough testing (van Teijlingen and Hundley, 2002). The researcher promptly extended the time limit upon notification.

3.7.5. Administration of Round One

An email with a personalised Qualtrics survey link was sent to 61 prospective expert panellists on September 19th, 2023. Six were ineligible or unavailable, leaving 54 potential participants. After two weeks, only 22 questionnaires were completed. A reminder email on October 1st, 2023, yielded 16 additional submissions (Appendix i). The survey closed on October 8th, 2023, with 38 experts participating, resulting in a 70% response rate.

Anonymised responses were exported to QSR NVivo software (release 1.6.1) for thematic content analysis. NVivo was chosen for its data import capabilities and free availability. It facilitates organizing, analysing and visualizing data to identify patterns (NVivo®, 2024).

3.7.6 Qualitative Data Analysis

Thematic content analysis was employed to analyse survey responses from the first qualitative round. This method, as described by Braun and Clarke (2006), allows researchers to identify, investigate and report themes across qualitative data. Content analysis frameworks aim to group similar statements together and examine if they can be collapsed into one statement without losing meaning (Keeney, Hasson and McKenna, 2011). Analysing the full dataset from the start allows researchers to highlight similarities and differences in responses and gain insights early (Clarke and Braun, 2017). Researchers can adopt a deductive approach with preconceived themes or use inductive coding to build "patterns, categories, and themes from the bottom up" (Creswell, 2009, p.175).

There are a number of different content analysis frameworks, but all have the aim of grouping similar statements together and then undertaking further examination to determine if they can be collapsed into one statement without losing meaning (Keeney, Hasson and McKenna, 2011). Considering the full dataset from the onset enables the researcher to highlight similarities and differences in the responses and gain further insights into the data at an early stage (Clarke and Braun, 2017). A deductive approach can be adopted, in which researchers come to the data with some preconceived themes. Alternatively, inductive coding involves building "patterns, categories, and themes from the bottom up" (Creswell, 2009, p.175).

For this study an inductive approach was adopted, allowing themes to emerge from the data. The analysis followed a modified version of Braun and Clarke's (2006) six-step process. The initial stage involved familiarisation, where responses are carefully scrutinised multiple times. This process was important to gain a deeper understanding of the content and immerse oneself in the data (Srivastava and Thomson, 2009). The initial impressions of each response were recorded, noting whether they held overall positive or negative views about the future. In addition, any important ideas or unusual phrases were highlighted.

The subsequent phase was coding, which involves conceptualising data into meaningful categories (Bowling, 2014). Different coding processes were employed for various types of qualitative questions. For questions 6 and 7, which included experts' predictions for pharmacy by 2030, a list of words and short phrases was generated. Similar items were grouped and truncated into concise codes. A frequency calculation was conducted to ascertain popularity. Categories were divided into 'digital technology/automation' and 'AI/machine learning' to facilitate the development of questions for the second round. Question 8, which looked at projections for 2050, was analysed in a similar manner. For the next set of questions, a traditional inductive or open-coding process was followed, with codes arising directly from the dataset. This method involves reading survey responses in groups, annotating the text and generating descriptive codes that capture the essence of what was described. The text was reread and coded. As subsequent groups of surveys were examined, relevant previous codes were applied, and new codes were generated as necessary. All responses were reviewed to determine if further categorisation was required. This iterative process continued until all data had been analysed and no further codes were generated. This approach ensured comprehensive and unbiased coding, minimising preconceived ideas held by the practitioner researcher and allowing insights and themes to emerge organically from the data.

Due to commonalities in responses to questions 9-12, these data were combined into one large dataset. Codes were reviewed, grouped, and attributed to higher-level categories following Miles and Huberman's (1994) method. Seven distinct categories emerged, which

were then categorized into three overarching themes: Workforce, Culture/Human factors, and Strategy/Infrastructure in Wales. This is shown in Table 8 overleaf.

Using a systematic approach, statements from respondents were categorised under appropriate themes, following Keeney, Hasson, and McKenna (2011) to group expert panel statements into similar domains. This facilitated the development of statements and organisation of the questionnaire for the next round.

Table 8. Coding themes, categories and codes.

THEMES	Workforce		Culture/ Human factors		Strategy & Infrastructure in Wales		
							Digital
	x		x				
	x		x				
	x		x				
	x	x	x	x	x		
	x		x	x			
	x	x	x				
	x		x				
			x	x			
	x		x	x			
					x		x
					x		x
					x		x
			x			x	
	x		x				
	x		x				
			x		x		x
						x	x
						x	x
					x	x	x
	x		x		x		x
			x		x		x
					x		x
						x	x
						x	x

3.8 ROUND TWO

The initial qualitative data was converted into statements for subsequent rounds. Despite potential lower response rates with more items (Gargon *et al.*, 2019), accurately representing experts' views remained crucial. Sufficient time was allocated for developing robust statements, adhering to Delphi technique principles (Jaam *et al.*, 2022). To maintain engagement, diverse question types were employed. Four-point Likert scales assessed agreement with 2030 pharmacy predictions, focusing on expected outcomes rather than personal preferences (Blease *et al.*, 2018). Ranking scales determined 2050 priorities.

3.8.1 Developing the Quantitative Questions

The themes and sub-categories from the second set of qualitative questions were analysed, condensed, and consolidated into universal descriptions while preserving meaning and specificity (Hasson, Keeney and McKenna, 2000; Olsen *et al.*, 2021). Verbatim phrases and vocabulary from the first round were retained with minimal editing. By incorporating the panel's specific wording, the researcher maintains the authenticity of the participants' voices throughout the study. This method not only preserves the nuances and contextual understanding of the topic but also increases the likelihood that respondents in future rounds will comprehend and relate to the statements. Furthermore, this technique aligns with best practices in qualitative research, as it maintains reliability and minimises researcher bias (Keeney, Hasson and McKenna, 2011).

The resulting themes were categorised into nine sections for improved readability, resulting in 41 questions for the second round. A covering email and information page were included to provide guidance and express appreciation for the experts' contributions. Participants were informed that statements were based on their own words to enhance confidence in the researcher's analysis.

3.8.2 Likert Measurement Scale

Validated measurement scales, particularly Likert scales, are commonly used in quantitative studies to measure phenomena (Parahoo, 2006). Likert scales are ordinal scales that quantify opinions on various issues (Bishop and Herron, 2015). Although the scale has some

limitations, as the intervals between the choices may not be equitable or linear (Bishop and Herron, 2015), it was an appropriate instrument to use for the questions in this study, where the purpose was to measure the level of agreement and develop consensus on the statement (Keeney, Hasson and McKenna, 2011).

The number of response points in Likert scales varies across studies. Jaam *et al.* (2002) found that five-point scales are most common, but this study ultimately used a four-point scale, following Blease *et al.*'s (2018) approach. This decision aimed to avoid neutral options and compel participants to make a definitive assessment, potentially enhancing data quality (Krosnick *et al.*, 2002). For analysis, responses were dichotomised into positive and negative opinions to determine consensus, similar to Blease *et al.*'s (2018) study. The importance of statements was measured using the mean rank of each response, as in Blease *et al.*'s (2020) later study.

3.8.3 Ranking Questions

Another type of question used in the survey was a ranking question. Respondents ranked a list of suggestions made by panellists in the first round, in order of favourability or priority. Care was taken to ensure clear and explicit instructions for completing these questions (as advised by Gray, 2018). A drag-and-drop format captured the ranking data, where respondents placed options into their preferred order using the mouse. Blasius (2012) finds this approach best suited for ranking data in web surveys.

3.8.4 Consensus

Consensus in research is generally defined as agreement among group members, often described as "gathering around median responses with minimal divergence" (Murry and Hammons, 1995, p. 423). In Delphi studies, there is no standardised consensus threshold, with researchers using varying levels from 20% to 100% agreement, though most use greater than 60% (Niederberger and Spranger, 2020). Some studies lack clear consensus definitions or fail to explain their rationale for chosen targets (Olsen *et al.*, 2021). This study set a pre-analysis consensus level of greater than 70% participant agreement or disagreement,

replicating Volkmar *et al.* (2022) and exceeding McKenna's (1994) suggested 51% target. This level was chosen as a strong yet pragmatic cut-off given time and resource constraints.

3.8.5 Piloting the Round Two Survey

The original reviewers piloted Round Two, providing feedback on participant information, instructions, survey flow, statement readability and questionnaire length. They offered positive feedback, noting the survey's comprehensiveness and clear structure. Recommendations to number questions and reformat Likert-scale queries were implemented to improve readability. Pilot participants completed the survey in under 10 minutes, which was communicated to participants in the accompanying email to set time expectations.

3.8.6 Administration of Round Two

The second-round survey was sent by email to 38 experts on November 23, 2023 (refer to Appendices j and k), although one had retired since Round One. After two reminders (Appendix l), 33 responses were received by December 10, 2023, yielding an 89% response rate. The anonymized data was transferred from Qualtrics to Statistical Package for the Social Sciences (SPSS®) from IBM®, version 29 for analysis.

3.9 ROUND THREE

The third round followed the second round's format, but statements with over 70% expert agreement were removed to shorten the questionnaire and encourage completion of the final round (de Villiers, de Villiers and Kent, 2005; Keeney, Hasson and McKenna, 2011). Gargon *et al.* (2019) caution specifically about retaining all the questions in subsequent Delphi rounds. While it might seem to offer more comprehensive data, repeating a long list of questions could potentially be burdensome for participants and lead to increased panel attrition.

Participants reconsidered 13 non-consensus statements, with previous round's agreement percentages included for the Likert scale questions. The two future priority ranking questions were presented in full, showing cumulative percentages of high-priority options (first or second choices). For these questions, the stability of the group responses was considered in

the analysis. The cover email, reminder emails and screenshots from the final Qualtrics survey are shown in Appendices m-o.

The turnaround time between rounds was reduced due to simpler survey construction on Qualtrics (repurposing Round Two questions) and the need for sensitivity during the upcoming Christmas period, where most respondents would take holidays or face workplace pressure. The survey was piloted with positive feedback about the shorter survey and inclusion of the detail of the responses from the previous round. The final round was sent on December 15th to the 33 Round Two respondents. After initial and follow-up requests, 32 responses were received by January 9th, 2024, achieving a 97% response rate. Data analysis began in January 2024, comparing findings against the learning from the literature review.

3.9.1 Quantitative Data Analysis

SPSS was utilised for quantitative analysis of participants' responses. SPSS was selected due to the researcher's familiarity and its ability to perform necessary descriptive statistics. It was also readily available from the university. Descriptive statistics in the form of frequencies were used to report percentage agreement with statements or likelihood of predictions. Responses to Likert-scale questions were grouped into positive opinions (strongly agree and somewhat agree, very likely and somewhat likely) or negative opinions (disagree and strongly disagree, unlikely and very unlikely). This determined whether the pre-set consensus of greater than 70% expert agreement or disagreement had been achieved or needed reconsideration in the next Delphi round.

SPSS functionality was used to determine the "level of importance" of statements within the context of other rated statements, as suggested by Keeney, Hasson and McKenna (2011, p.90). Numerical values ranging from 1 to 4 were assigned to response options. For predictive questions, a value of 1 denotes Very likely, whereas a value of 4 indicates Very unlikely; for agreement questions, a value of 1 represents Strongly agree, and a value of 4 signifies Strongly disagree. SPSS calculates the mean of responses which was used to determine the level of importance of each statement. A lower mean value corresponds to a higher level of importance attributed to the statement by participants. Statements with

mean values closer to 1 were deemed more significant within the study's context. This methodology facilitated a nuanced analysis of the data, emphasising key statements and future priorities identified by the respondents, and the findings were subsequently used to inform the discussion.

3.10 CHAPTER SUMMARY

This third chapter has detailed the research methodology and activities undertaken to address the research questions. The Delphi technique was chosen due to limited available research and its capacity to systematically build consensus through iteration. The researcher's professional network in Wales facilitated assembling a panel of knowledgeable experts from various Pharmacy sectors to address the research questions.

A traditional Delphi method was followed, employing an electronic survey tool for questionnaire development and data collection. The initial qualitative round required participants to provide free text responses about short- and long-term predictions for digital technology and AI in pharmacy, describe distinctive features of the Welsh pharmacy context, and potential risks or concerns.

Careful coding and thematic analysis of first-round data resulted in 41 questions for subsequent rounds. To enhance reliability, efforts were made to retain phrases and vocabulary verbatim from the initial round. Four-point Likert scale questions tested agreement with statements, and ranking questions determined future priorities for emerging technology. A consensus target was set at greater than 70% expert agreement or disagreement with each statement, selected as a robust yet pragmatic cut-off point given time and resource constraints. To mitigate attrition, only questions and statements not achieving consensus were re-evaluated in the final Delphi round.

The next chapter presents the results obtained from the three rounds of the Delphi process. A comprehensive analysis of the qualitative data will provide insights into key themes and ideas from the expert panel's responses. Data from subsequent quantitative rounds will display how consensus among experts evolved throughout the Delphi process.

Chapter 4. Results

4.1 INTRODUCTION

The results chapter presents a comprehensive analysis of the data collected through the three rounds of the Delphi study. Demographic data of the panellists are presented and tracked throughout the rounds. Results of the coding and thematic analysis of the qualitative data gathered from the first round are shown. Direct quotations from participants' free-text responses are included to provide insights into the experts' perspectives. The organisation of the data into emerging themes helped facilitate the development of statements for subsequent quantitative rounds. The data from the Likert-scale and ranking questions were analysed using a statistics package and the results are displayed utilising graphs and tables. Consensus levels achieved for the Likert statements highlight areas of agreement and divergence among the panellists. An examination of any shifts in opinion that occurred between rounds for the participants' ranking future priorities for pharmacy is detailed, providing insights into how the iterative process influenced the panellists' perspectives.

4.2 PARTICIPANT PROFILE

Prospective expert participants were initially asked a series of qualifying and demographic questions. Each participant was assigned a unique reference number, facilitating the linkage of data across all rounds. Table 9 overleaf presents the demographics of the participants who completed each Delphi round. It is evident that the composition of the panel remained relatively consistent throughout the study.

Table 9. Comparison of participant profile in first, second and third Delphi rounds.

Demographic	Response	R1 frequency n (%)	R2 frequency n (%)	R3 frequency n (%)
Location*	Wales	38 (100%)	33 (100%)	32 (100%)
	England	2 (5%)	2 (6%)	2 (6%)
	Rest of UK	3 (8%)	3 (9%)	3 (9%)
Experience (years)	0- 5	0	0	0
	>5-10	1 (3%)	1 (3%)	1(3%)
	>10- 20	6 (16%)	5 (15%)	5 (16%)
	>20	31(84%)	27 (82%)	26 (81%)
Area of expertise*	Community Pharmacy	9 (24%)	7 (21%)	7 (22%)
	Hospital/ Acute Pharmacy	19 (50%)	19 (58%)	19 (59%)
	Primary Care Pharmacy	11 (29%)	10 (30%)	9 (28%)
	General Practice	5 (13%)	3 (9%)	2 (6%)
	Academia/ Education	7 (18%)	7 (21%)	7 (22%)
	Government	4 (11%)	3 (9%)	3 (9%)
	Professional body/ Regulation	4 (11%)	4 (12%)	4 (13%)
	Other (please give details)	6 (16%)	6 (18%)	6 (19%)
Age (years)	25 or younger	0	0	0
	>25- 35	1 (3%)	1 (3%)	1 (3%)
	>35- 45	10 (27%)	9 (27%)	9 (28%)
	>45- 55	20 (54 %)	17 (52%)	16 (50%)
	>55	7 (19%)	6 (18%)	6 (19%)
Sex	Female	18 (47%)	17 (52%)	16 (50%)
	Male	20 (53%)	16 (48%)	16 (50%)

* Participants were able to select more than one option

The following figures provide a detailed graphical depiction of the different participant characteristics from the first-round responses.

4.4.1 Clarification of Location

Figure 4 shows the location of the respondents in the first round. All 38 respondents in the first round confirmed that they worked in Wales and were eligible to participate in the study. Three participants indicated that they worked in 'England' or the 'Rest of the UK' as well.

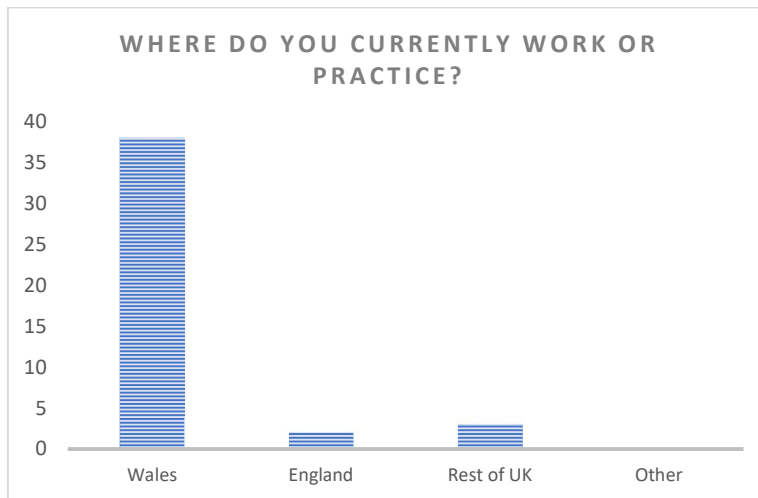


Figure 4. Location of participants in Round One (frequency).

4.2.2 Experience in Pharmacy

The purpose of this question was to determine the level of experience that participants had in the field of pharmacy. A considerable proportion of the participants (84%) indicated that they had more than 20 years of experience, while six respondents (16%) reported having been in pharmacy for between 10 and 20 years. Furthermore, one participant (3%) stated that they had between 5 and 10 years of experience. Figure 5 illustrates the breakdown.



Figure 5. Years of pharmacy experience for participants in Round One (frequency).

4.2.3 Area of Expertise

Participants were requested to indicate their areas of expertise within pharmacy. They were able to choose multiple categories from a provided list, or they could select 'Other' and specify their own descriptor. Fifty percent of the respondents (n=19) opted for Hospital/Acute Pharmacy, while 29% (n=11) selected Primary Care Pharmacy and 24% (n=9) chose Community Pharmacy. Additionally, 18% (n=7) of the respondents reported having expertise in Academia/Education and 13% (n=5) selected General Practice. Furthermore, 11% (n=4) of the participants identified as having expertise in Professional Body/Regulation and Government sectors. Six respondents who selected 'Other' specified areas such as Community Integrated Services, Medicines Advice, Special Health Authority, Transformation, Advisory Group and Negotiating Body. Notably, no responses were received from pharmacists working in the Pharmaceutical Industry.

Of the nineteen participants who selected only one sector, Hospital/Acute Pharmacy was the most commonly reported single area of expertise (n=8). Moreover, ten participants reported having expertise in two sectors, while six participants had expertise in three sectors and two participants had expertise in four different sectors. The data is illustrated in Figure 6 below.



Figure 6. Area of expertise in pharmacy of participants in Round One (frequency).

4.2.4 Age of Participant

The fourth demographic question requested information regarding the age range of the participants. The majority of respondents (54%) were aged between 45 and 55 years old (n=20), while 24% were aged between 35 and 45 years old (n=9). Additionally, 19% of participants were older than 55 years (n=7) and only one individual (3%) was aged between 25 and 35 years. The results are shown in Figure 7.

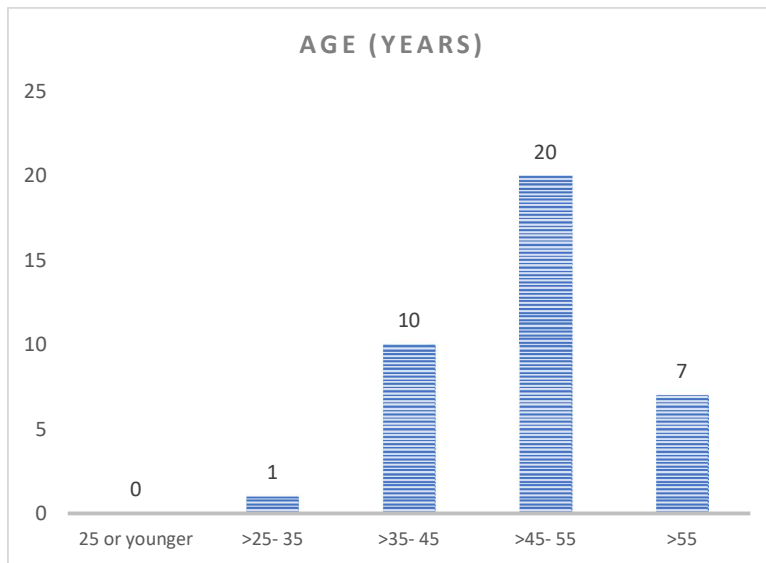


Figure 7. Age ranges of participants in Round One (frequency).

4.2.5 Sex of Participant

All participants provided their response to the question. In the initial round, 20 males (53%) and 18 females (47%) participated, as shown in Figure 8. At the time of the analysis, an FOI request was made to the UK Pharmacy governing body to compare this against the UK and Welsh registered pharmacists (shown in Appendix p)

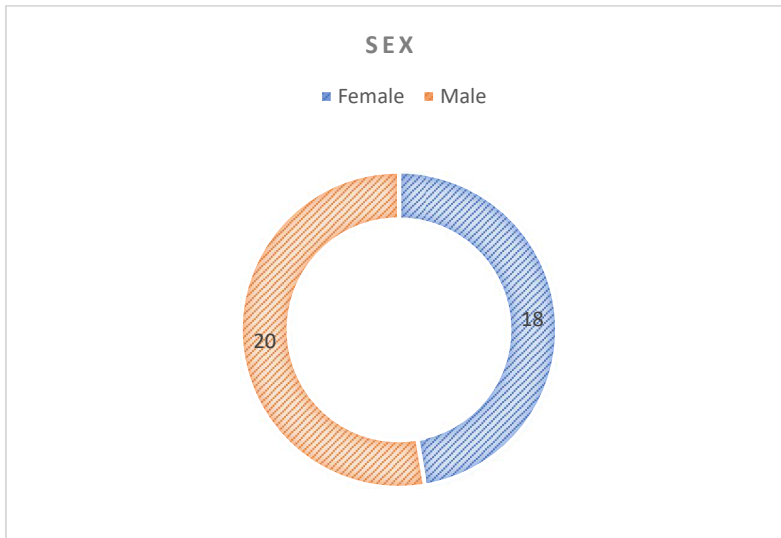


Figure 8. Sex of participants in Round One (frequency).

4.2.6 Recruitment Strategy

As outlined in the previous chapter, owing to the constraints of time, it was not feasible to contact all 61 prospective panellists prior to the study to assess their eligibility and encourage their participation. Table 10 illustrates the response rates for the various recruitment methods utilised to assemble the expert panel. It is evident that all individuals who were contacted prior to the study successfully completed all the Delphi rounds. It is worth noting that a formal email sent to an unfamiliar contact was the least effective recruitment and retention strategy.

Table 10. Comparison of recruitment strategy and response rate through the study.

Recruitment approach	Emails sent n	Potential eligible participants n	Completed R1 n (% of eligible)	Completed R2 n (% of R1)	Completed R3 n (% of R1)
Approached before the study	14	14	14 (100%)	14 (100%)	14 (100%)
Informal email to known contact	30 (1 declined)	29	18 (62%)	15 (54%) (1 retired after R1)	14 (48%)
Cold email	17*	11	6 (55%)	4 (36%)	4 (36%)
Overall	61	54	38 (70%)	33 (87%)	32(84%)

* 4 not pharmacists, 1 off work, 1 email address not in use.

4.2.7 Summary

In summary, the demographic findings reveal that the majority of respondents work exclusively in Wales and have over two decades of experience as pharmacists. The highest proportion of respondents are from the hospital pharmacy sector, followed by primary care, community, and academic settings, in descending order. The age range of participants is mainly between 45 and 55 years, with a fairly even split between men and women. Throughout the study, the demographic composition remained largely consistent, though hospital pharmacists were most likely to complete all three rounds. The most successful method for recruiting and retaining panellists was establishing direct contact with potential participants prior to the study's commencement.

4.3 DELPHI ROUND ONE

The second section of the Round One survey aimed to gather qualitative data through open-ended questions. Participants were instructed to provide their answers in their own words. This data was used to inform the development of questions for the subsequent Delphi rounds. The length of their responses varied significantly, ranging from no response or a single word to extensive multiple paragraphs. The average length of each response was 26.2 words, with a standard deviation of 15.66. Notably, the question (question 9) asking the panel about the preparedness of pharmacy in Wales to use digital technology and AI elicited the longest average response (31.8 words). This was closely followed by question 6 (average 31.6 words), which sought predictions on how technology and AI would assist pharmacy by 2030. These

findings dispelled concerns of survey fatigue due to the number of qualitative questions included. A more detailed breakdown of response length for each question is shown in Appendix q.

4.3.1 Forecasting Questions

The first page of free-text questions asked the panel to write about their predictions for the future of technology and AI in pharmacy.

By 2030, what tasks and roles in pharmacy do you think could be assisted by digital technology and artificial intelligence?

To analyse the first open-ended question, a process of dataset familiarisation was conducted initially (Clarke and Braun, 2017, p. 297). Following this, a detailed list of words and brief phrases used by the participants was compiled (as shown in section 6.5.2). This list was then reviewed and consolidated into similar categories or codes. Certain codes were excluded from the final list as they were beyond the scope or influence of pharmacy. The final column in the table illustrates the precise wording that was used for each specific code to develop the statements for the subsequent rounds. In order to improve reliability, it was important to capture the general essence of the items grouped under each code, while incorporating direct quotes from Round One narrative, wherever feasible (Keeney, Hasson and McKenna, 2011). Figure 9 below illustrates the most frequently identified words in the written responses to this question.



Figure 9. Word cloud to provide overview of the most frequently identified terms from R1 question 6, namely 2030 predictions of pharmacy tasks and roles to be assisted by digital technology and AI. *

**The size of the font of a word is determined by the frequency of the word.*

In regard to the potential tasks and roles in pharmacy that could be assisted by digital technology and artificial intelligence by the year 2030, the highest frequency suggestion by the panel members was the dispensing or supply of medication. They also believed that pharmacists could be supported in clinical checking and prescription validation. Accuracy checking of prescriptions and providing patient information were also popular suggestions. Table 11 displays the codes with the highest frequency of participant comments included in each respective code.

Table 11. Highest frequency codes from analysis of Round One responses to 2030 predictions of pharmacy tasks and roles to be assisted by digital technology and AI.

Identified codes	Frequency	Words/ phrase chosen for R2
Dispensing/ supply	16	dispense prescriptions
Clinical checking/ validation	14	assist Pharmacists when “clinically checking prescriptions”
Accuracy checking	9	“accuracy check dispensed medication”
Patient information	9	“provide patient advice and counselling through chat function assistant”
Procurement & invoicing	8	medicines procurement and invoicing
Training & education	5	“aid development, delivery and assessments for education and training”
Automated cabinets	4	supply medicines through automated cabinets across sectors
Shared Medication record	3	“share or transfer patient medication data between healthcare providers”

By 2030, what tasks and roles in pharmacy do you think could be fully replaced by digital technology and artificial intelligence?

A second question asked the panel what tasks they thought could be entirely replaced by the year 2030. A similar coding procedure to the preceding question was used to analyse the responses. There were considerable overlap and repetition of ideas from the prior query. Table 11 illustrates the most frequently occurring codes derived from the participants' responses, alongside the corresponding wording that was selected for the statements in Round Two.

Common predictions by the panel included the automation and digitalisation of tasks such as dispensing, procurement and invoicing by 2030. Many also suggested that the task of accuracy checking of dispensed medication would be replaced within this timeframe. Codes that exhibited a high frequency in this question, i.e., the panel believed would be fully undertaken by technology and AI by 2030, were phrased accordingly in the subsequent rounds.

Table 12. Highest frequency codes from analysis of Round One responses to 2030 predictions of pharmacy tasks and roles to be replaced by digital technology and AI.

Identified codes	Frequency	Words/ phrase chosen for R2
Dispensing/ supply	24	dispense prescriptions
Procurement/ invoicing	19	medicines procurement and invoicing
Accuracy checking	11	"accuracy check dispensed medication"
Sharing patient data	3	"share or transfer patient medication data between healthcare providers"
Patient education/ counselling	2	"provide patient advice and counselling through chat function assistant"
No change	2	no more than the current situation

Are there other potential applications that you foresee for digital technology and AI in pharmacy?

The panel was asked to suggest future potential application of digital technology and AI for pharmacy. The text was analysed in a similar manner involving coding and frequency calculations. Figure 10 below illustrates the most frequently identified words in the written responses to this question.



Figure 10: Word cloud to provide overview of the most frequently identified terms from R1 question 8, namely future potential for digital technology and artificial intelligence in pharmacy. *

**The size of the font of a word is determined by the frequency of the word*

Many participants thought fully automated, closed-loop medication systems would be a future possibility. Others mentioned the potential of AI in pharmacogenomics and clinical checking, while many suggested the benefits of fully integrated and accessible digital health records for pharmacy. The most frequently mentioned codes are presented Table 13 overleaf, along with the selected illustrative words and phrases that were derived from the participants' responses.

Table 13. Highest frequency codes from analysis of Round One responses of future potential for digital technology and artificial intelligence in pharmacy.

Identified codes	Frequency	Words/ phrase chosen for R2
Fully automated medicines supply	12	“closed loop medication supply systems (from procurement through to transportation to end user)”
Pharmacogenomics	6	“full genomic profiling to guide optimum prescribing and generate individualised treatment plans”
Digital health records	6	“fully integrated digital health record accessed across all NHS organisations”
AI clinical checking	5	“clinical checking of prescriptions to reduce avoidable adverse drug reactions and drug interactions”
Patient counselling & advice	3	“AI chatbots managing patient queries and providing advice”
Self-management/ monitoring	3	“monitoring patients’ conditions and medication compliance through data from patient wearables and devices”
Medicines information	3	“provision of medical information, literature searching and interpretation of clinical studies”
Pharmaceutical production	3	drug development and manufacturing
Big data	2	“analysis of ‘big data’ to inform evidence based prescribing and horizon scanning”
AI- business & workforce	2	“supporting pharmacies with business intelligence and workforce demand management”

4.3.2 Other Questions Relating to Pharmacy in Wales

During the open coding of the subsequent four questions displayed below, numerous parallel concepts were identified through the development of comparable or duplicate codes. As the inductive coding process progressed, cross-cutting themes and subcategories emerged from the dataset by combining the responses (Creswell, 2009). The questions were:

To what extent do you think Pharmacy in Wales is prepared to be able to utilise and harness digital technology and artificial intelligence?

What concerns or risks for Pharmacy do you have with the use of digital technology and artificial intelligence?

What advantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?

What disadvantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?

As outlined in Table 7 in the methods chapter, three central themes of Workforce, Culture/Human factors and Strategy/Infrastructure in Wales and seven subcategories (Skills, Training, Profession, Patients, Governance, Finance and Digital) were identified and refined during the thematic analysis of the participants' comments. This process facilitated the grouping of common ideas and the formulation of the statements for the subsequent Delphi rounds. Detail of the themes is shown below, with illustrated quotes provided for further information and clarity.

4.3.3 Theme 1: Workforce

Within the broader theme of workforce, the majority of respondents expressed concerns about digital capabilities and expertise of the current pharmacy workforce. The following are some of the comments made by the panel on this topic:

“Lack of IT skills in all roles” (Participant #19)

“Average individual [has] low digital expertise” (Participant #1)

“Need for expertise not just digital awareness in pharmacy” (Participant #18)

A widely held view that emerged was the necessity to develop the skills of the entire workforce to fully integrate and utilise new technologies (Participant #42). However, several participants pointed out the absence of digital training for pharmacy. Some participants believed that the perceived skill gap in pharmacy was more a result of a lack of willingness to engage (Participant #13), a lack of ambition to adopt technology (Participant #18) or the aging profile of the pharmacy workforce. A few respondents emphasised the need to support and

develop the role of clinical informatics pharmacy professionals in delivering digital advancements in pharmacy.

The subject of role replacement was also coded under this theme, but it also emerged in the human factor theme that is discussed later. In response to Question 10, which asked the panellists about the risks associated with the use of technology and AI in pharmacy, a common concern was the potential displacement of human pharmacists and technicians by robots and machines in the workplace. A representative quote reflecting this apprehension is as follows:

“Loss of roles for highly skilled workforce” (Participant #18)

The opinions expressed by the participants were divergent regarding the potential consequences of AI on the future of patient care. For instance, Participant #19 expressed concerns about the over-reliance on AI leading to a loss of clinical judgment and deskilling. Conversely, Participant #62 acknowledged the rapid advancements in technology but emphasised the importance of maintaining the human touch in patient care. However, there were also remarks that highlighted the potential benefits of technology in enhancing the workforce. The following statements exemplify this.

“[AI] supporting clinical decision making” (Participant #4)

“Release staff to undertake patient facing roles” (Participant #24)

“Enhanced efficiencies and safety” (Participant #24)

4.3.4 Theme 2: Culture and Human Factors

The second theme to emerge was Culture and Human Factors. This had considerable overlap with the workforce theme, with numerous responses featuring duplicate codes.

Several participants emphasised the need for a cultural shift to fully realise the benefits of technology in pharmacy. For instance, one participant stated that *“Hospital pharmacies*

remain very traditionally operated and the cultural change required to progress such technology will take time” (Participant #18), whilst another noted that *“needs to be a culture shift around seeing what technology can offer and embracing that rather than seeing it as something to be feared”* (Participant #4). Additionally, another participant highlighted the need for *“a drastic change in the culture within Pharmacy... to be more accepting of digital technology”* (Participant #61).

While some respondents discussed differences in the adoption of technology between pharmacy sectors, others noted that other health professions were more open to using digital tools and AI. One stated that with pharmacy had a *“lower profile”* in digital projects (Participant #9), while others mentioned the profession lacking ambition and being risk averse.

However, it is important to recognise that not all participants expressed negative opinions about their profession and its readiness to adopt technology. Some of them had optimistic views, such as one participant who stated that *“lot of passionate and driven individuals working within pharmacy that want to see a change”* (Participant #61) and another who noted that *“pharmacies would welcome more digitisation/ automation”* (Participant #46).

The participants also highlighted the significant advantages of having pharmacists involved in supporting patients and overseeing technology and AI algorithms in the future. For instance, Participant #12 emphasised the importance of maintaining human interpretation and interaction with patients, as this is where the details about patients' medication use are discovered. Similarly, Participant #36 stressed the need to ensure that AI supports decision-making without replacing it, while Participant #42 underscored the value of preserving the personal touch and face-to-face element of pharmacy, as providing reassurance and advice often works better in person.

4.3.5 Theme 3: Strategy and Infrastructure in Wales

The third overarching theme that developed from the analysis was described as Strategy and Infrastructure in Wales. This theme encompassed insights into healthcare strategy and

governance, digital infrastructure of NHS Wales and the extent of collaboration between different organisations across the country. The theme and its subcategories were primarily derived from the responses to questions 11 and 12 in the initial round of data collection. The experts were asked to identify any advantages or disadvantages associated with pharmacy in Wales in relation to the implementation of technology and AI.

Many respondents highlighted the positive impact of the relatively small size of the country. For example, one participant noted that *“As a small nation, large scale change is easier to manage and can be filtered to all more easily, hopefully making Wales an ideal site to trial advances”* (Participant #31). Another participant agreed, stating that *“Small nation should be able to be nimble in adopting and adapting new technologies”* (Participant #19). Additionally, another participant pointed out the *“Relatively small and well-integrated community - ability to make things happen as a nation”* (Participant #4).

Furthermore, some respondents were optimistic about the ability for the limited number of organisations in Wales to work collaboratively and implement change through *“established networks”* (Participant #17). Additionally, there were comments about the rurality of Wales, which encouraged digital development and improvements in patient access. However, not all participants held the same viewpoint. Negative opinions were expressed, as evidenced by the following statements:

“Size hinders large scale digital investments” (Participant #12)

“Wales is generally slow to adopt technologies and there are many barriers” (Participant #53)

Furthermore, some panellists emphasised the lack of funding and investment for digital development in Wales, while others thought this issue extended to the NHS and wider public sector across the UK. In addition, the inadequacy of IT systems and programs to communicate and interface effectively was cited as a limiting factor. Comments were made about the immaturity of the digital infrastructure and the inability to disseminate pockets of innovation and best practices across the NHS.

The panel expressed diverse opinions regarding Digital Health and Care Wales (DHCW), the special health authority established by the Welsh Government in 2021 to replace the previous Wales Informatics Service. DHCW was set up to provide a more system-wide approach with a national responsibility for delivering digital and data health and care services (Downey, 2021). Many of comments concerned the organisation and its approach to digital developments, had a negative tone. Similar observations are made by Whitfield and Hamblin (2023), who report that various stakeholders in Wales express confusion about the role of DHCW and cite instances of a lack of transparency and poor communication. In this study participants stated:

“DHCW is distant from the realities of the frontline” (Participant #16)

“Pace of work for suppliers (inc. DHCW) can be 'glacial'” (Participant #46)

“National approach via DHCW dealing with the separate organisations in my opinion hinders development and increases the costs” (Participant #12)

However, some participants were complementary about DHCW and their management of the national digital platform for Wales. The quotes below illustrate this point:

“[Wales is] well-placed with DHCW as a designated body overseeing [digital development]” (Participant #17)

“Work well as "one Wales"... close to Welsh Gov policy/drivers” (Participant #1)

Others advocated for further collaborative work to standardise systems and processes and ensure *“greater consistency in use of technology in healthcare”* (Participant #9) across Wales. A risk identified by one respondent was:

“Different health boards will continue to develop and commission different technologies with no once for Wales approach” (Participant #61)

One participant made a connection between DHCW and the profession's vision for Pharmacy in Wales writing:

“Coherent vision with PDaHW. Willing partner with DHCW” (Participant #28)

Another participant positively commented on the profession's vision:

‘Having a national strategy in PDaHW including cover digital ambition is a useful tool to support change but needs to be backed meaningfully. (Participant #12)

Others praised the strong leadership within the Pharmacy profession in Wales for enabling digital development and innovation.

4.3.6 Summary

The data collected from the initial three qualitative questions in Round One revealed the highest frequency responses from the panel regarding the roles and tasks in pharmacy they believed could be assisted or fully replaced by digital technology and AI by 2030 and suggestions for long-term technological developments. Thematic analysis of the aggregated data from the remaining four questions identified three overarching themes: Workforce, Culture/Human factors, and Strategy/Infrastructure in Wales, which facilitated the categorisation and formulation of statements for the subsequent round.

4.4 DELPHI ROUND TWO

As outlined in the preceding chapter, findings from the first round were utilised to construct the questions for the subsequent round. The survey was divided into nine distinct sections, to improve the layout and readability with the aim of enhancing the completion rate. The second round consisted of 41 questions in total, utilising two distinct question formats to measure the panel's level of agreement or prioritisation for each statement.

4.4.1 Likert Scale Questions- Round Two

There were 39 Likert scale questions included in the survey. These investigated the panel's opinions regarding the use of technology and AI in pharmacy in Wales by the year 2030, as well as their views on the pharmacy workforce, strategy, digital infrastructure in Wales and the profession, in relation to technological advancements.

Predictions on the use of Digital Technology and Automation in pharmacy by 2030

The first section of questions comprised of a series of statements, for which the panel members were required to indicate their level of agreement regarding whether the tasks or roles described would commonly be performed by digital technology and automation by the year 2030. Figure 11 below illustrates the percentage of responses to the different statements.

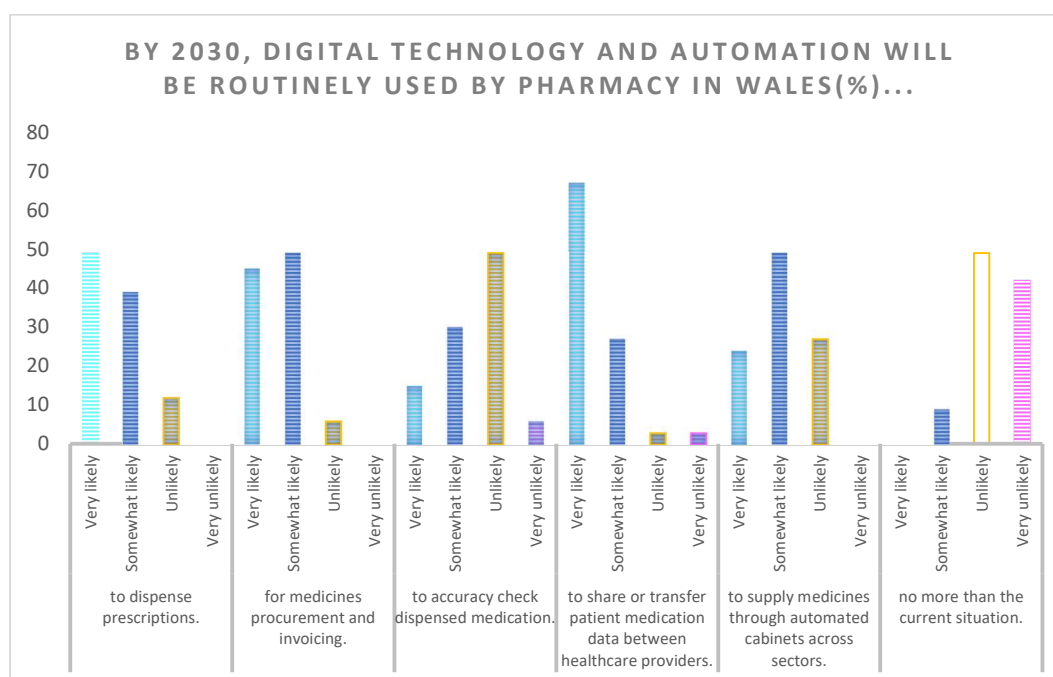


Figure 11. Participant responses to statements in Round Two Question 1 (percentage).

Of the six statements presented to the expert panel, five gained consensus agreements in the second round. One statement from this section was subsequently considered in Round Three. Further information on this is provided below.

Dispense Prescriptions: Consensus

Consensus was achieved for the first statement where 88% of participants (n=29) thought that digital technology and automation will be commonly used to dispense prescriptions by 2030. Specifically, 16 individuals (49%) indicated that this outcome was 'very likely,' while 13 (39%) stated that it was somewhat likely', as illustrated in Figure 12.

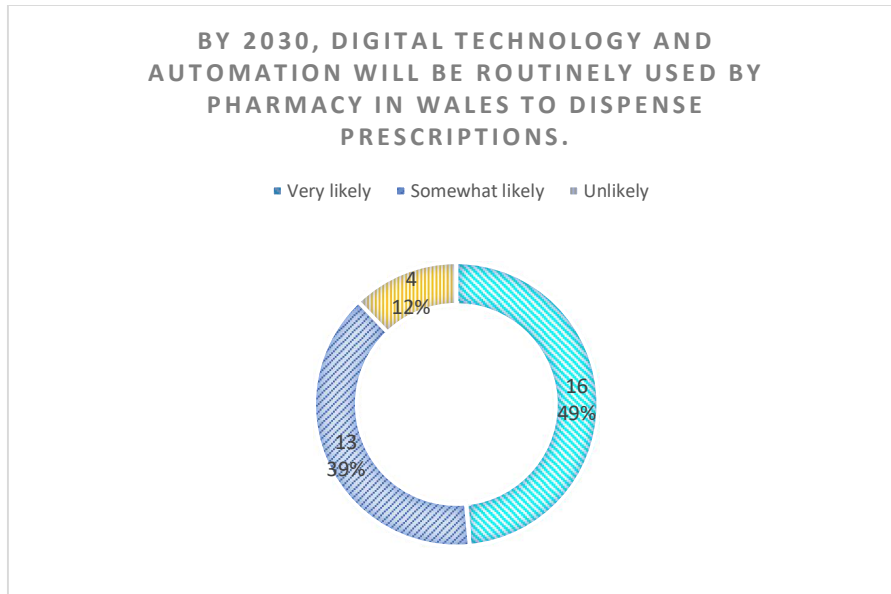


Figure 12. Participant responses to statement 1A Round Two.

Medicines Procurement and Invoicing: Consensus

A consensus was reached that digital technology and automation would be routinely utilised by pharmacy in 2030 for the procurement and invoicing of medicines. 94% of the experts surveyed agreed with this statement. 49% (16) of the respondents indicated that this was somewhat likely, while 45% (15) believed it was very likely. This is shown in Figure 13 overleaf.

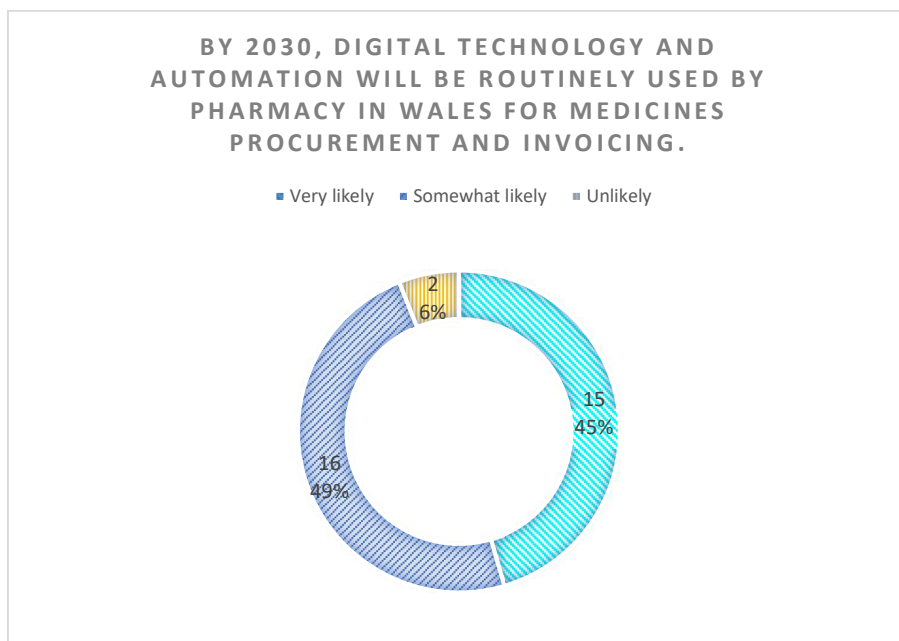


Figure 13. Participant responses to statement 1B Round Two.

Share and Transfer of Medication Data: Consensus

There was a strong consensus that there will be the ability to share or transfer patient medication data between healthcare providers by 2030. As illustrated in Figure 14, 31 out of 33 pharmacists (94%) expressed confidence in this outcome, with 22 (67%) of them saying it was very likely.

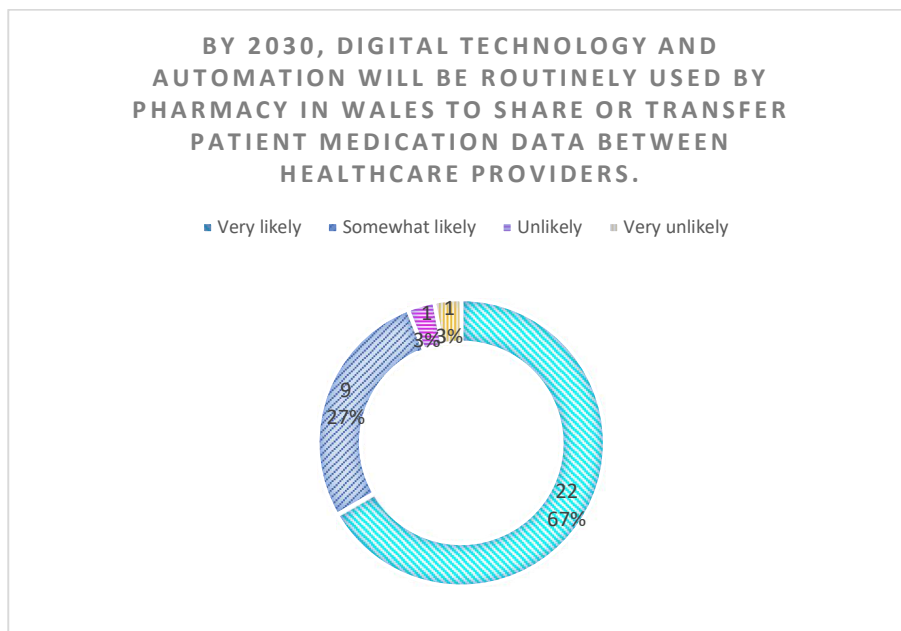


Figure 14. Participant responses to statement 1D Round Two.

Supply of Medicines Through Automated Cabinets: Consensus

A consensus of opinion was reached on the statement that medicines would be supplied through automated cabinets for all sectors of pharmacy by 2030. 24% thought it was likely and 49% said it was somewhat likely. Consequently, the cumulative agreement was 73% (n=24). This is depicted in Figure 15.

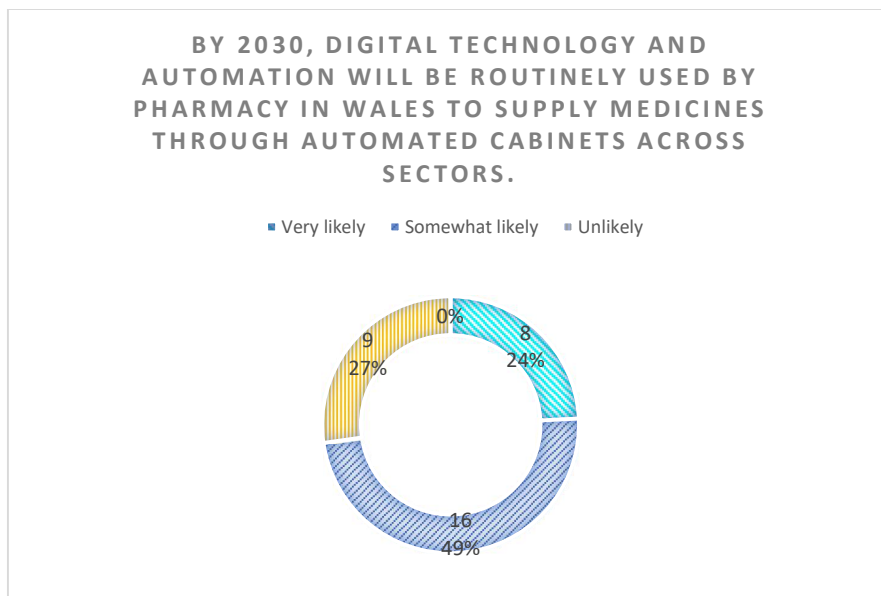


Figure 15. Participant responses to statement 1E Round Two.

No Change by the Year 2030: Consensus Disagreement

The statement indicated that there would be no change from the current usage of digital technology and automation in pharmacy in Wales by 2030. Here, there was a strong consensus against this notion, with 30 participants (91%) disagreeing, and of those, 14 (42%) stating 'very unlikely'. This is shown in Figure 16 overleaf.

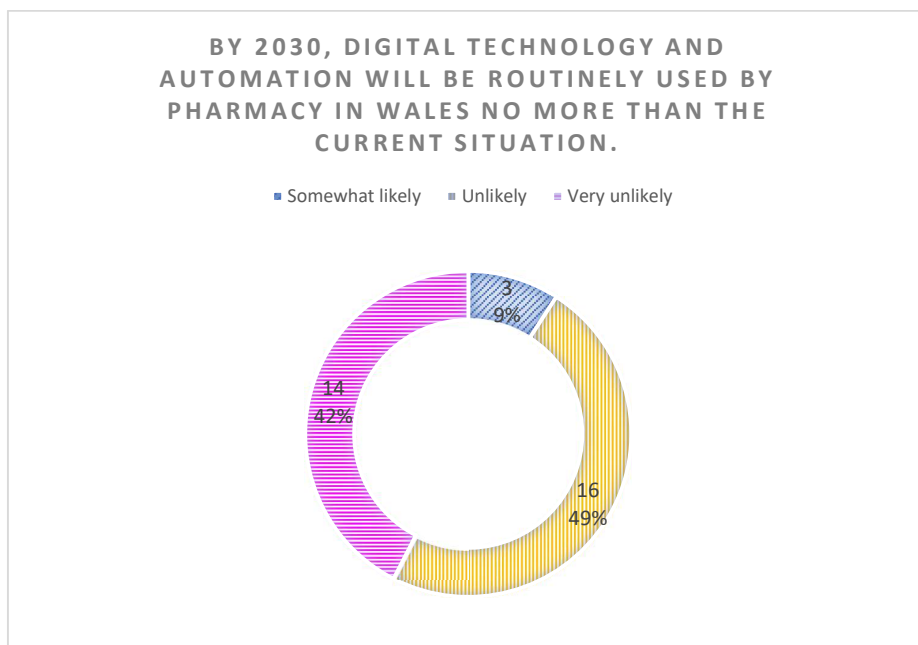


Figure 16. Participant responses to statement 1F Round Two.

Accuracy Checking of Dispensed Medication: No Consensus

This question asked whether the experts believed that the accuracy checking of dispensed medications would be routinely performed by technology by the year 2030. Figure 17 shows that the opinions in Round Two were divided, with 15 individuals (45%) expressing the belief that it was likely and 16 individuals (55%) indicating that it was unlikely. This statement was presented to the panel with the results from R2 in the third Delphi round.

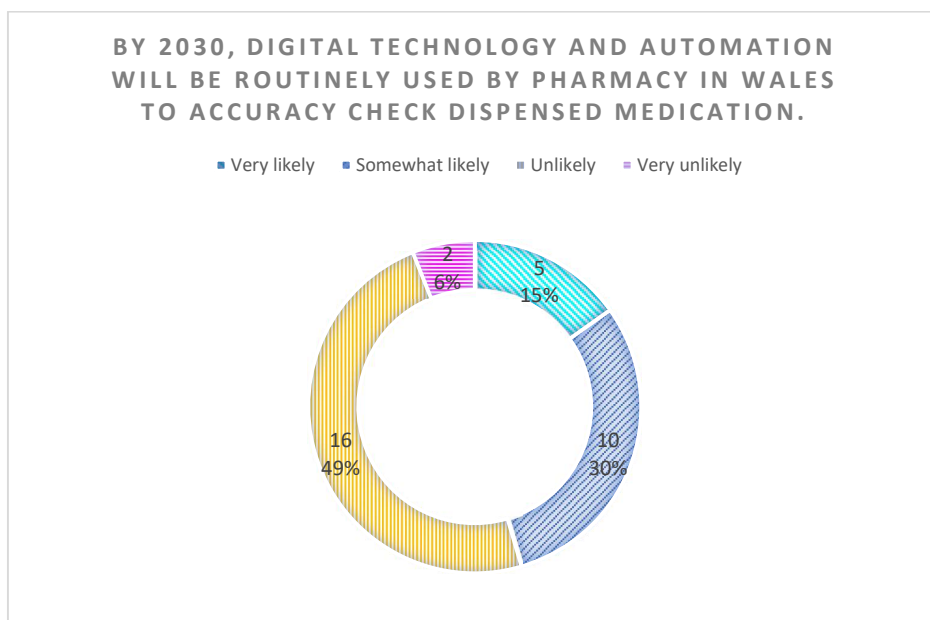


Figure 17. Participant responses to statement 1C Round Two.

Predictions for Uses of AI and ML in Pharmacy by 2030

The next section contained five statements asking the panel to forecast where AI and ML will be seen in pharmacy by 2030. During the construction of these statements, care had been taken to use ‘assist’ or ‘aid’ certain roles and tasks, as per the responses to questions 6 and 7 in the first round. Consensus was achieved by the panel for each of these statements in this particular round. The percentage responses for each of the statements are illustrated in Figure 18.

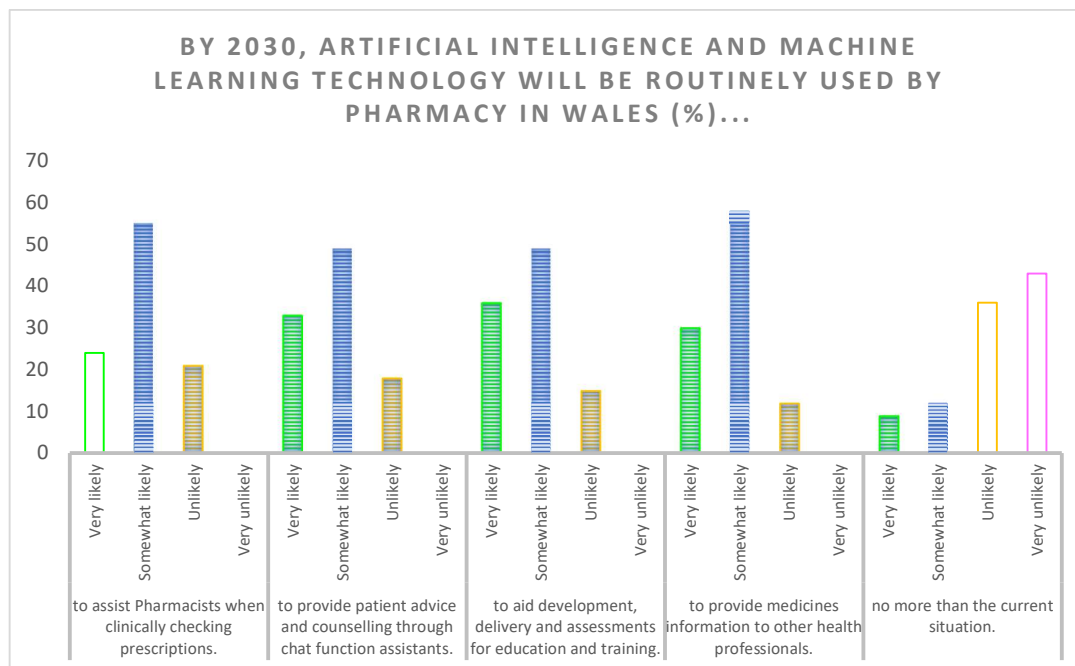


Figure 18. Participant responses to statements in Round Two Question 2 (percentage).

Assist with Clinical Checks: Consensus

A consensus was reached among the participants, with the majority (n=27, 79%) believing that AI and ML will be employed to assist pharmacists when clinically checking prescriptions by 2030. This is depicted in Figure 19 below, where eight participants (24%) selected the option of ‘very likely’ and 18 (55%) chose ‘somewhat likely’.

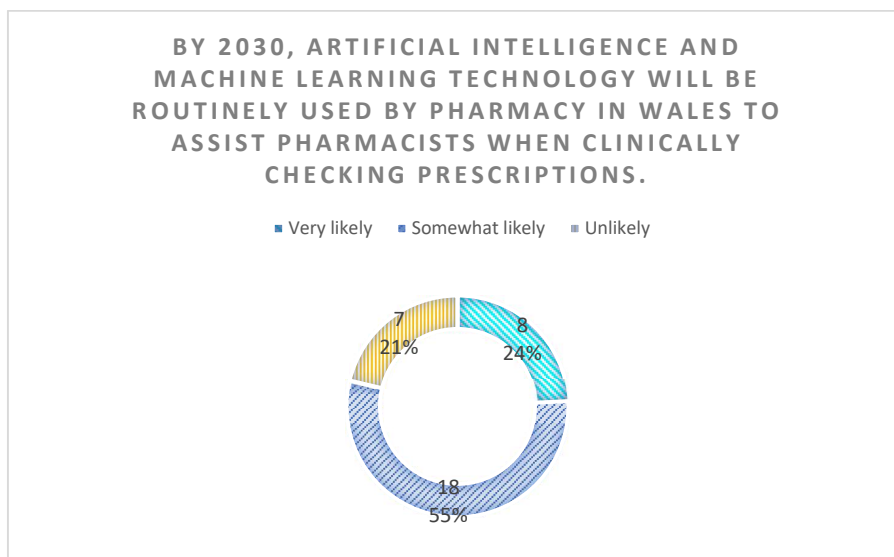


Figure 19. Participant responses to statement 2A Round Two.

Patient Advice and Counselling: Consensus

A consensus was achieved by the panel, with 27 experts (82%) opining AI and ML will provide patient advice and counselling through chat function assistants. As illustrated in Figure 20, 33% (11) of the participants held the view that this outcome was very likely, while 49% (16) considered it to be somewhat likely.

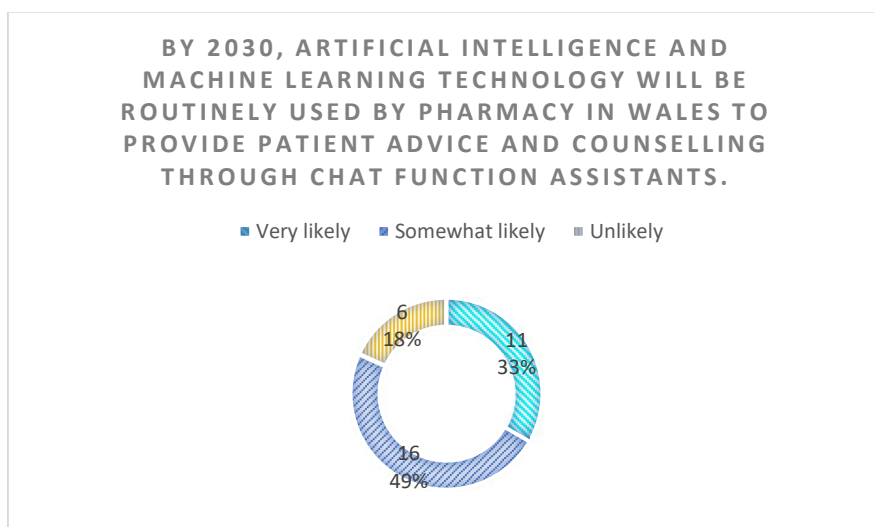


Figure 20. Participant responses to statement 2B Round Two.

Education and Training: Consensus

The panel reached a consensus of agreement on the use of AI and ML to aid the development, delivery and assessment for education and training. In total, 28 participants members (85%) believed that this was a likely outcome; of these, 12 individuals (36%) stated that it was very likely, while the remaining 16 (49%) were more cautious indicating that it was somewhat likely. This is illustrated in Figure 21.

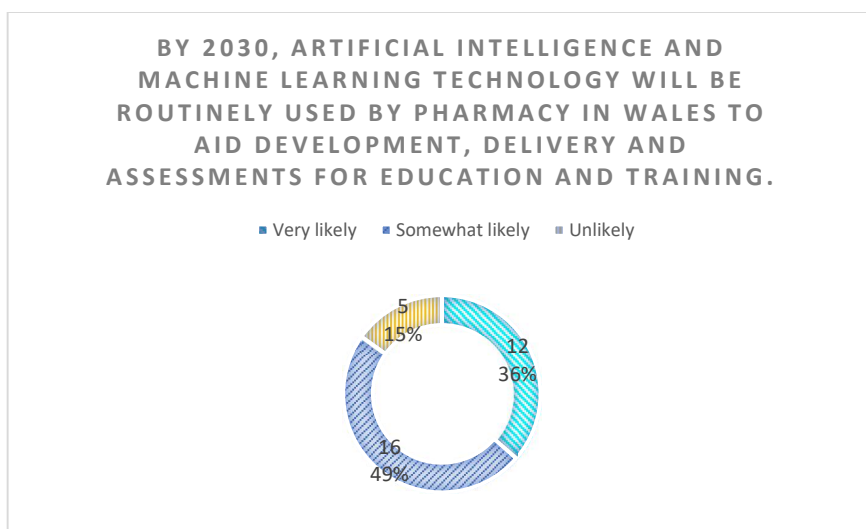


Figure 21. Participant responses to statement 2C Round Two.

Medicines Information: Consensus

This question asked if the experts on the potential use thought that AI and ML to provide medicines information to other health professionals. A consensus was reached in this round, with 29 panellists (88%) indicating that it was likely to occur by the year 2030. This is seen in Figure 22 overleaf.

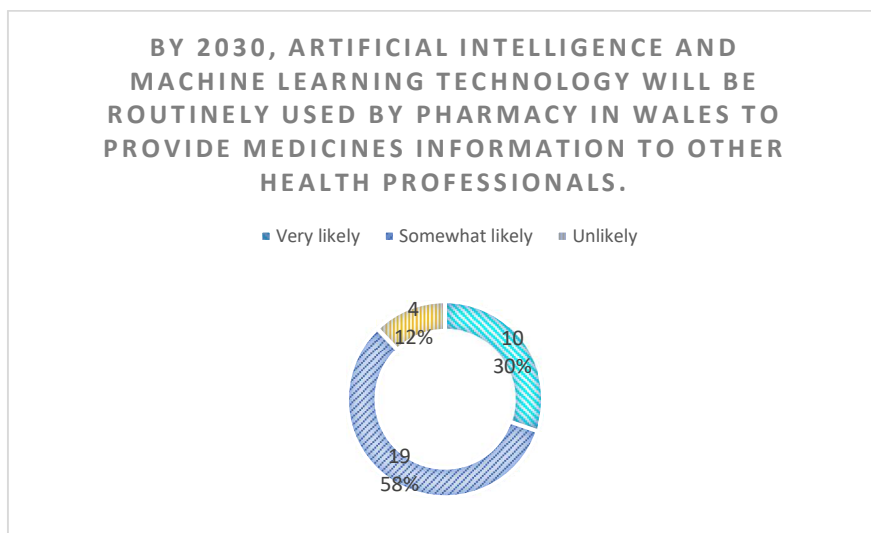


Figure 22. Participant responses to statement 2D Round Two.

No Change by the Year 2030: Consensus Disagreement

The final statement in this section stated that there would be no change from the current situation in the use of AI and ML by pharmacy by 2030. As demonstrated in Figure 23, there was a consensus reached against this opinion, with 26 participants (79%) thinking it was unlikely and of that 43% stating ‘very unlikely.’

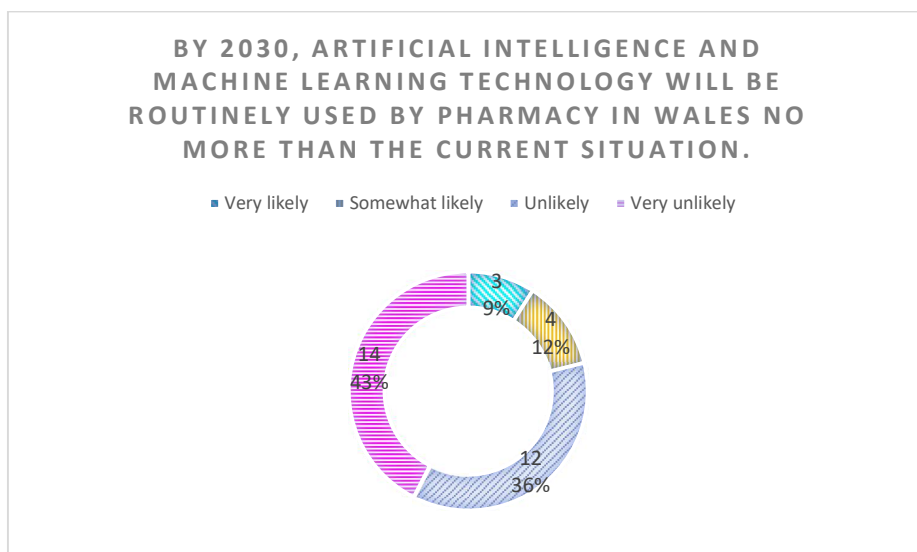


Figure 23. Participant responses to statement 2E Round Two.

Digital Infrastructure in Wales

The next set of Likert questions were developed from the opinions and wording expressed by participants during the first round regarding digital infrastructure in Wales. All but one of the

five statements presented to the panel achieved consensus in this round. The percentage breakdown of responses for each statement is illustrated in Figure 24 below.

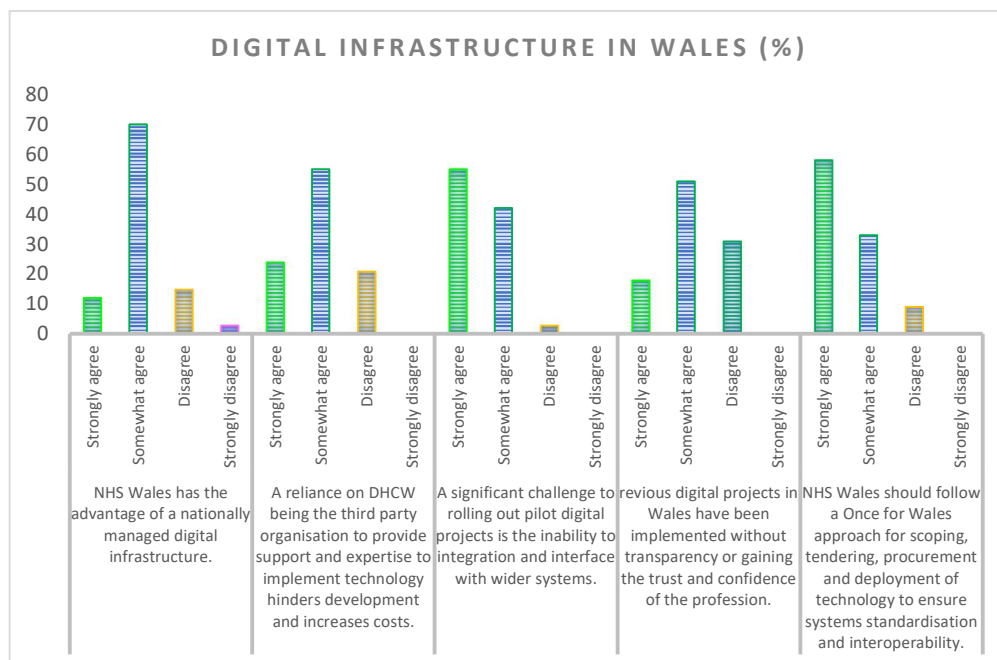


Figure 24. Participant responses to statements in Round Two Question 5 (percentage).

Nationally Managed Digital Infrastructure: Consensus

Twenty-seven participants agreed that NHS Wales had the advantage of a nationally managed digital infrastructure. Four panellists (12%) expressed strong agreement and 23 (70%) indicated some agreement. This signified that 82% of the panel reached consensus in this round. This is depicted in Figure 25 below.

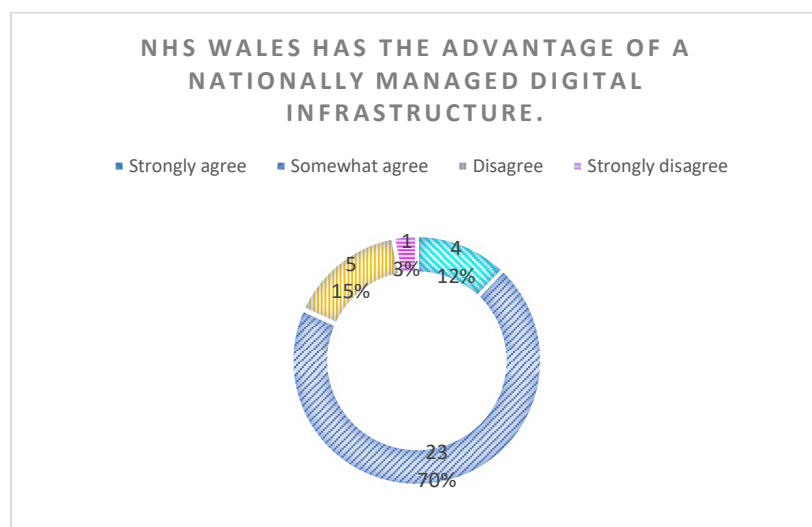


Figure 25. Participant responses to statement 5A Round Two.

DHCW Hinders Development and Increases Cost: Consensus

For the second statement, 26 participants (79%) agreed that the reliance on Digital Health and Care Wales (DHCW) as a third-party organisation to provide support and expertise to implement technology hinders development and increases costs. Conversely, 7 individuals (21%) dissented, although none expressed a strong disagreement as illustrated in Figure 26. Consensus was reached in this round.

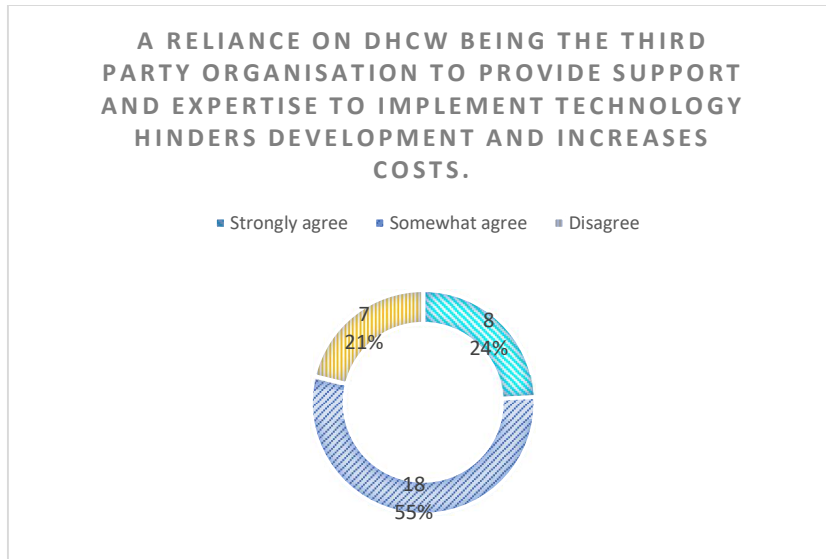


Figure 26. Participant responses to statement 5A Round Two.

Challenge of Integrating and Interfacing Systems: Consensus

As illustrated in Figure 27 overleaf, it is evident that a considerable proportion of the panel (97%) agreed that a significant challenge in rolling out pilot digital projects is the inability to integrate and interface with wider systems. Only one participant expressed disagreement, accounting for the remaining 3%.

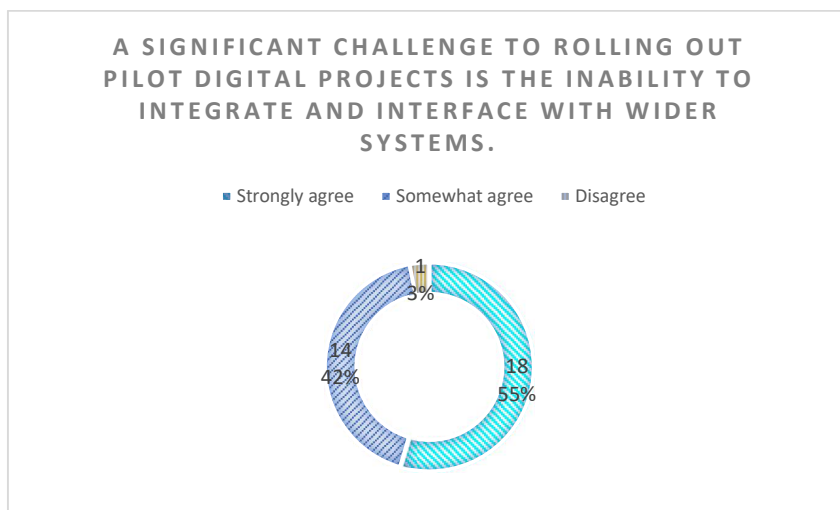


Figure 27. Participant responses to statement 5C Round Two.

'Once for Wales' Approach to Technology Implementation: Consensus

The final statement that reached consensus in this section asked the panel whether NHS Wales should follow a Once for Wales approach for scoping, tendering, procurement and deployment of technology to ensure systems standardisation and interoperability. A substantial majority of panellists (n=30, 91%) agreed, among whom 15 (58%) expressed strong agreement, as shown in Figure 28.

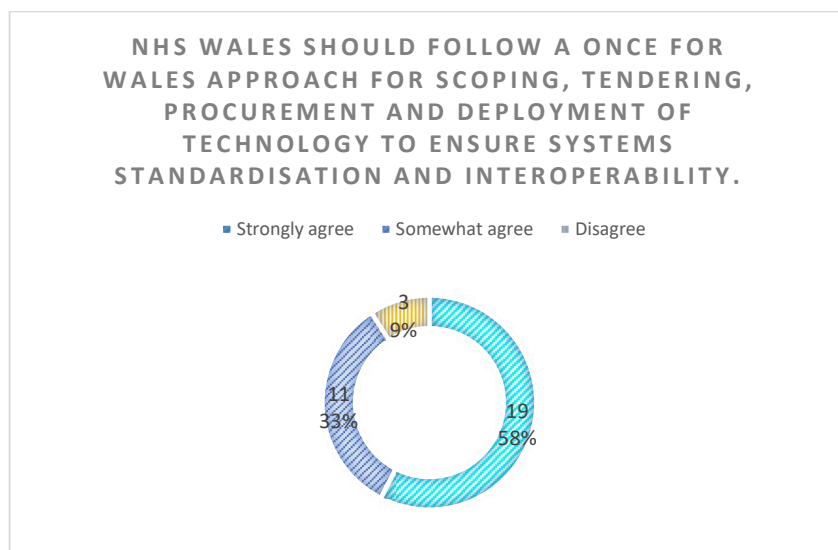


Figure 28. Participant responses to statement 5D Round Three.

Transparency and Trust in Past Projects: No Consensus

Consensus agreement was almost achieved in the second round for the statement 'Previous digital projects in Wales have been implemented without transparency or gaining the trust and confidence of the profession.' Figure 29 illustrates that 23 (69%) of the respondents agreed (51% indicated somewhat agree), while 10 (31%) dissented.

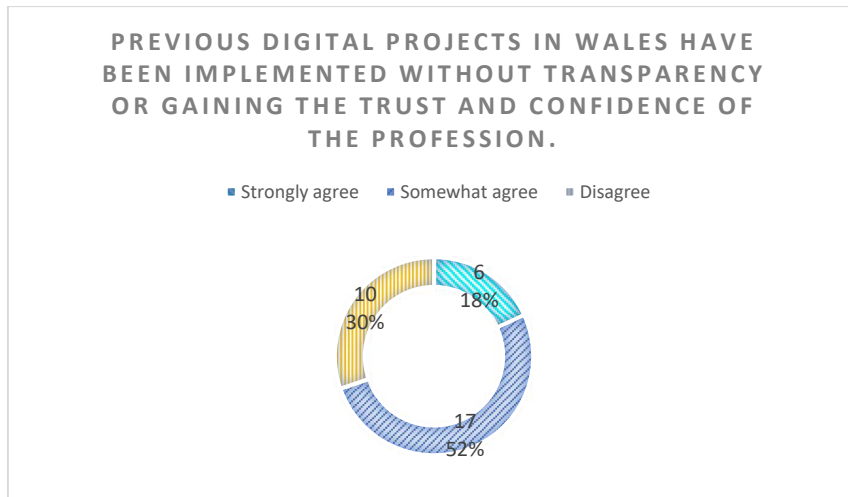


Figure 29. Participant responses to statement 5D Round Two.

Strategy in Wales

In this section participants were requested to indicate the extent to which they agreed or disagreed with five statements relating to strategy in Wales. Three statements failed to achieve consensus in Round Two, therefore they were revisited in the third Delphi round. The percentage responses are illustrated in Figure 30 overleaf.

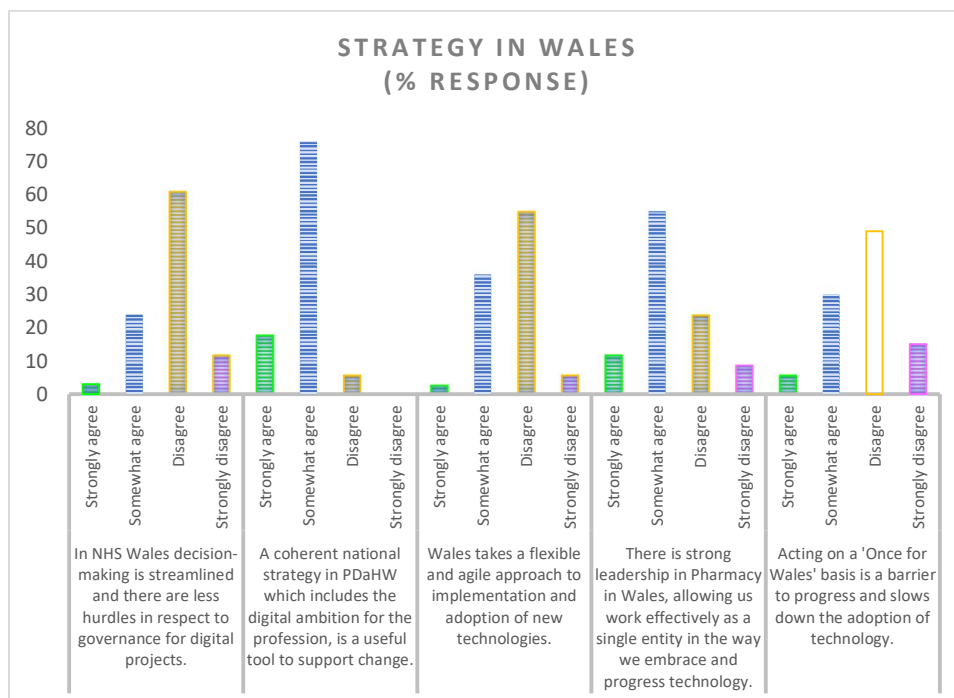


Figure 30. Participant responses to statements in Round Two Question 6 (percentage).

NHS Wales Decision Making: Consensus Disagreement

For this statement, significant number of respondents (24) disagreed that in NHS Wales decision-making is streamlined and there are less hurdles in respect to governance for digital projects. Among these, 20 individuals (61%) selected the option disagree and four (12%) expressed strong disagreement. This resulted in a combined consensus of disagreement amounting to 73%, as depicted in Figure 31.

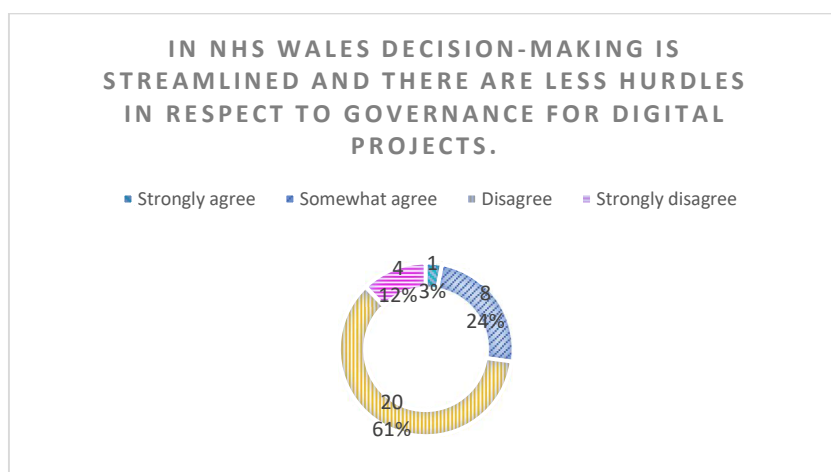


Figure 31. Participant responses to statement 6A Round Two.

Supportive National Strategy: Consensus

The vast majority of the panel members (94%), expressed agreement that a coherent national strategy in PDaHW which includes the digital ambition for the profession, is a useful tool to support change. Only two individuals, representing 3% of the sample, disagreed with this view. The results are shown in Figure 32.

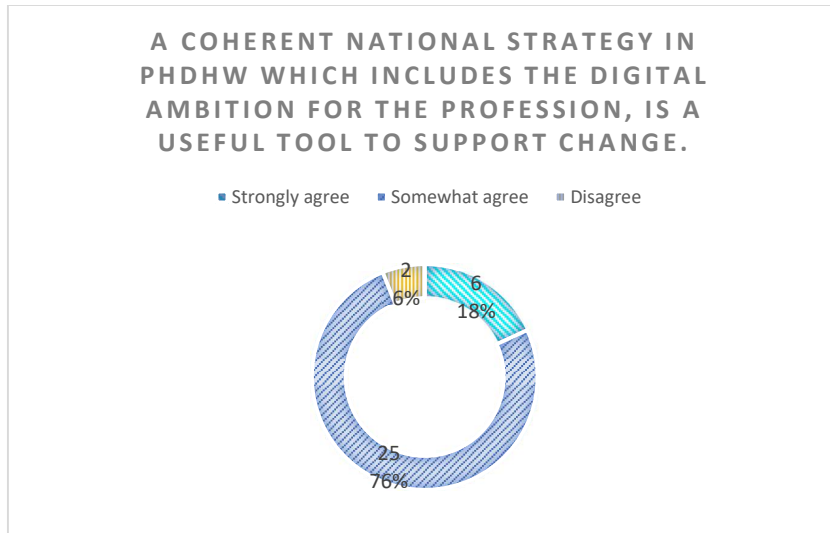


Figure 32. Participant responses to statement 6B Round Two.

Flexible and Agile Approach to Implementation: No Consensus

The panel failed to reach a consensus in this round on whether Wales takes a flexible and agile approach to implementation and adoption of new technologies. Out of the 39 participants, 13 (39%) agreed with the statement, while 20 (61%) held a dissenting opinion. This is depicted in Figure 33 overleaf.

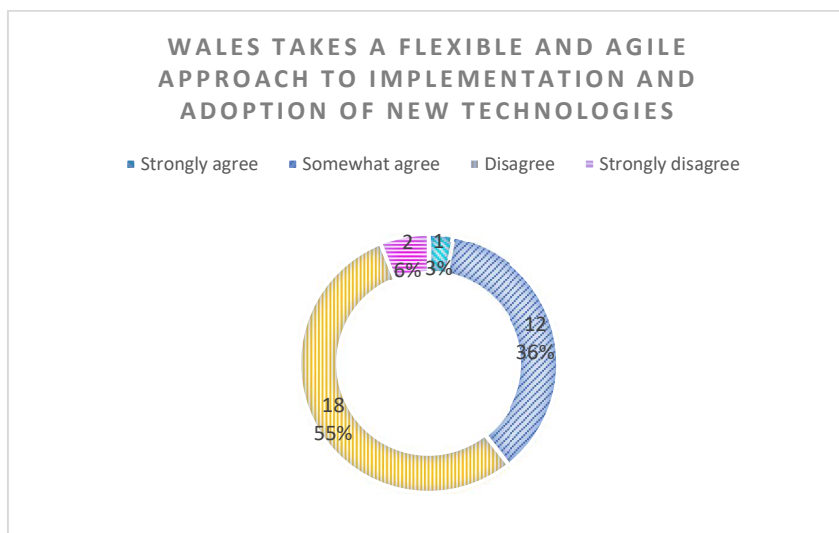


Figure 33. Participant responses to statement 6C Round Two.

Strong Pharmacy Leadership: No Consensus

As demonstrated in Figure 34 below, consensus was not reached in Round Two regarding the statement 'There is strong leadership in Pharmacy in Wales, allowing us to work effectively as a unified entity in embracing and progressing technology.' Twenty-two (67%) of the respondents agreed, with 55% selecting "somewhat agree," while 11 (33%) disagreed.

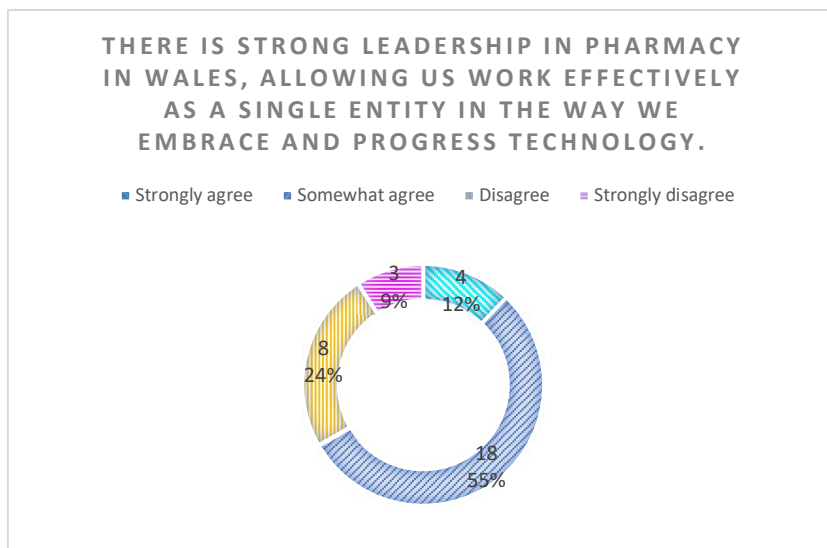


Figure 34. Participant responses to statement 6D Round Two.

Acting 'Once for Wales' is a Barrier: No Consensus

The final statement presented to the panel in this section was 'Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology.' In this round, there was no consensus reached; 12 participants (36%) agreed and 21 (64%) disagreed. Of the 21 participants who disagreed, five (15%) strongly disagreed with the statement. This is illustrated in Figure 35.

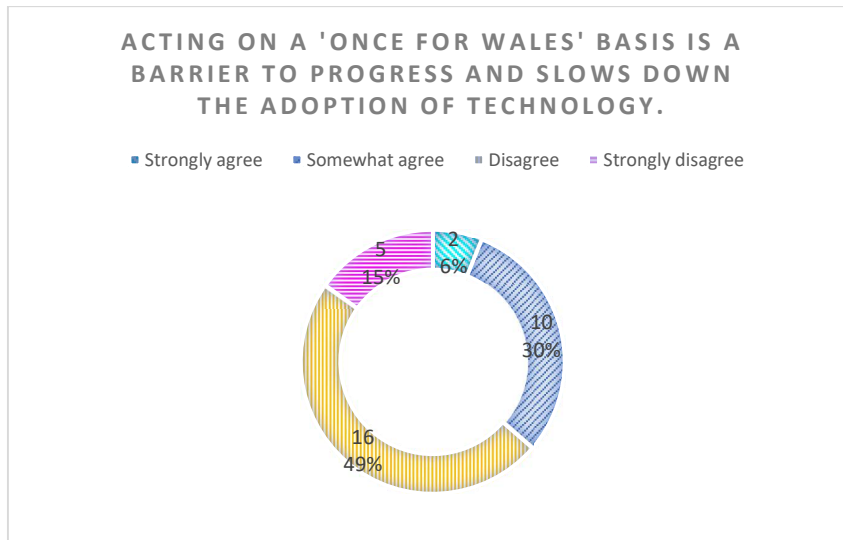


Figure 35. Participant responses to statement 6E Round Two.

Characteristics of Wales

This section contained five statements related to the characteristics of Wales in terms of healthcare and pharmacy, using the participants own words and phrases in the first survey round. Four of these statements achieved a consensus among expert opinions during this round, as illustrated in Figure 36 overleaf. One statement was reconsidered by the panel in the third Delphi round.

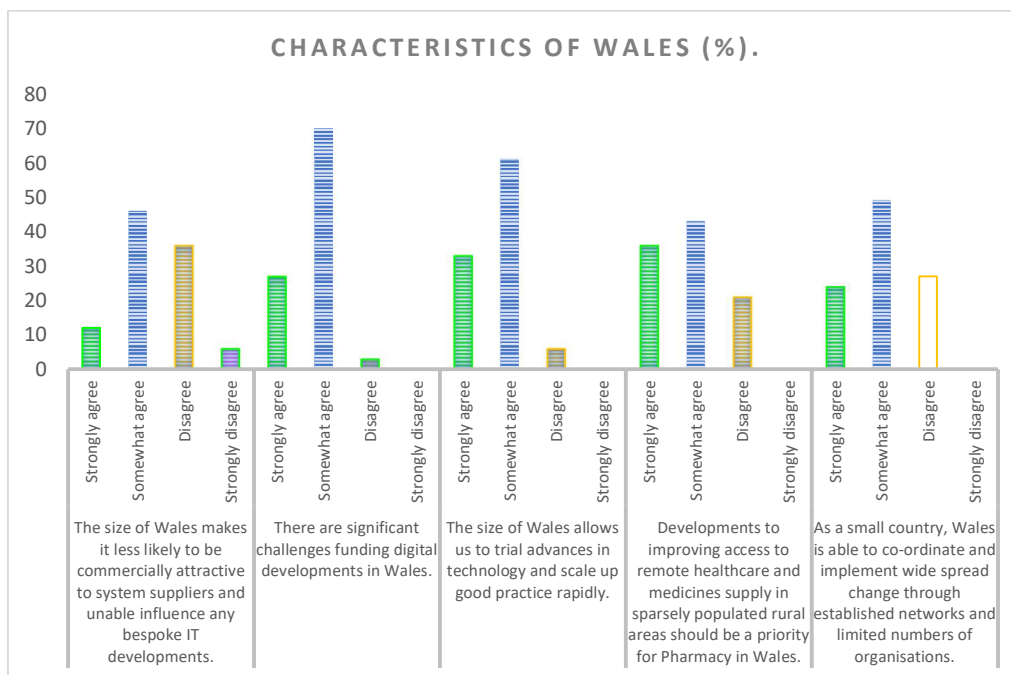


Figure 36. Participant responses to statements in Round Two Question 7 (percentage).

Challenges of Funding: Consensus

There was a strong consensus, amounting to 97% agreement, among the panel members regarding the significant challenges faced in securing funding for digital development in Wales. Only one panellist disagreed with this view (3%), while nine others expressed strong agreement (27%) and 23 individuals indicated some agreement (70%). This is illustrated in Figure 37.

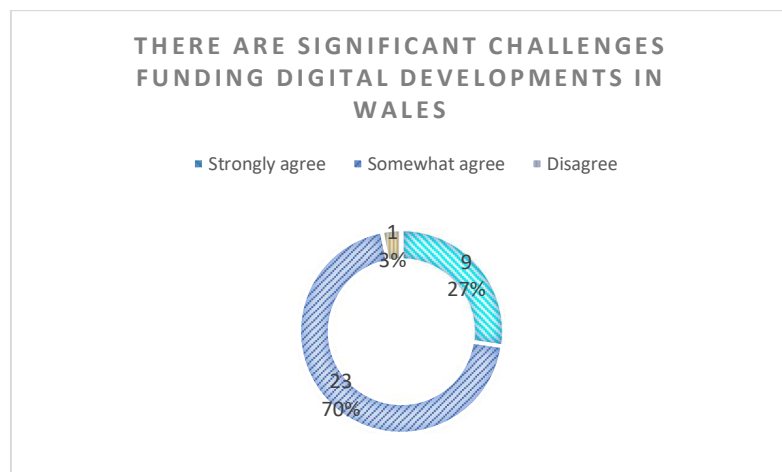


Figure 37. Participant responses to statement 7B Round Two.

Trial and Rapid Scale up Ability: Consensus

As depicted in Figure 38, there was a substantial agreement among the panellists regarding the statement ‘the size of Wales allows us to trial advances in technology and scale up good practice rapidly.’ Only two panellists held a dissenting view, while 31 (94%) were in agreement, with 11 (33%) expressing strong agreement. Consensus was achieved in this second round.

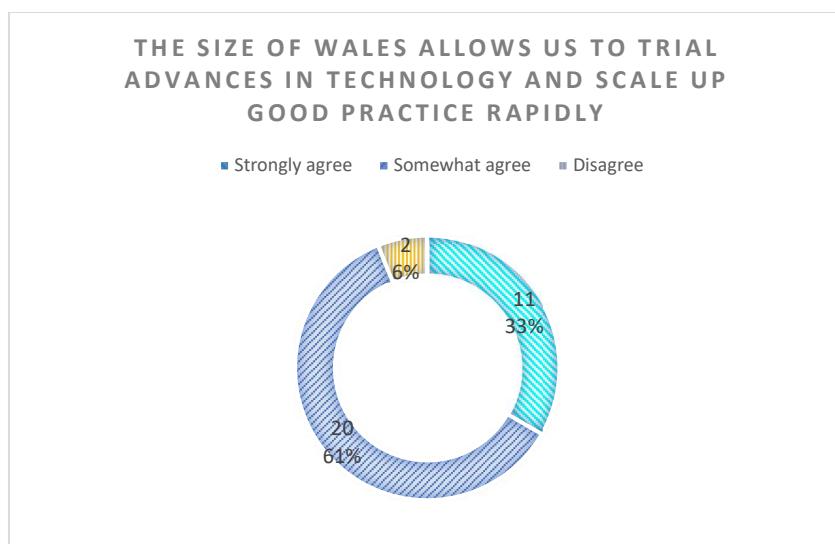


Figure 38. Participant responses to statement 7C Round Two.

Rural Focus: Consensus

For this statement, 26 participants (79%) concurred that developments to improve access to remote healthcare and medicines supply in sparsely populated rural areas should be a priority for pharmacy in Wales. Conversely, seven individuals (21%) expressed opposing views, but none of them strongly disagreed. A consensus was achieved by the panel in this round. This is shown in Figure 39 overleaf.

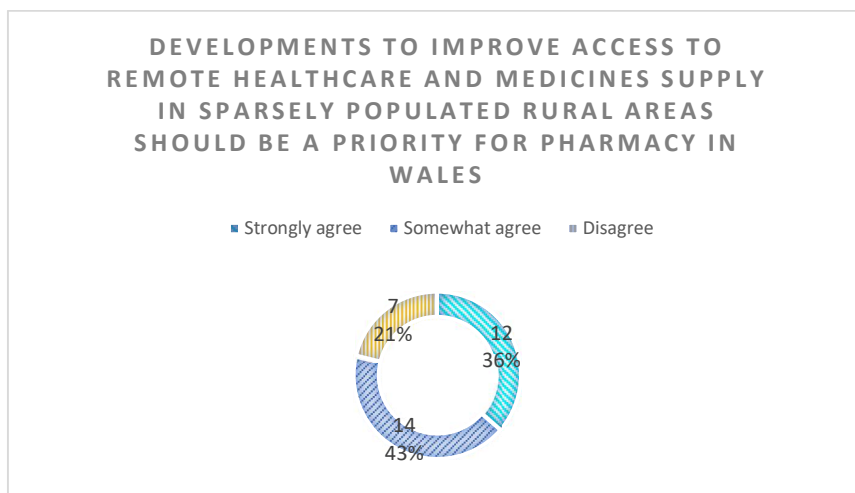


Figure 39. Participant responses to statement 7D Round Two.

Co-ordinating Change through Networks: Consensus

This statement asked the expert panellists if they agreed that as a small country, Wales is able to coordinate and implement widespread change through established networks and a limited number of organisations. The panel reached a consensus on this matter, with 24 respondents (73%) expressing their agreement. Among these, eight individuals (24%) strongly agreed with the statement, as depicted in Figure 40.

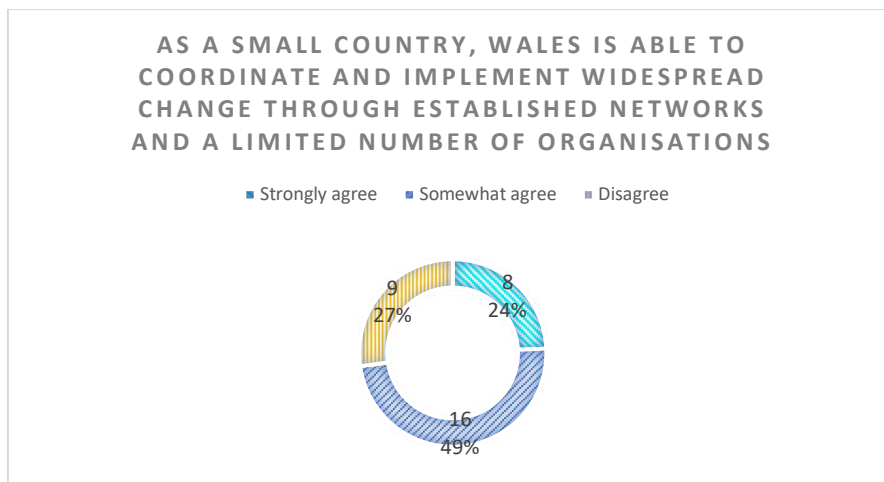


Figure 40. Participant responses to statement 7E Round Two.

Too Small Commercially: No Consensus

The opinion was divided on the statement ‘the size of Wales makes it less likely to be commercially attractive to system suppliers and unable to influence any bespoke IT developments.’ Nineteen participants (58%) agreed; of that four expressed strong

agreement. Fourteen disagreed and two members (6%) strongly disagreed. A consensus was not achieved, and therefore this statement was re-evaluated in the third round. This is demonstrated in Figure 41.

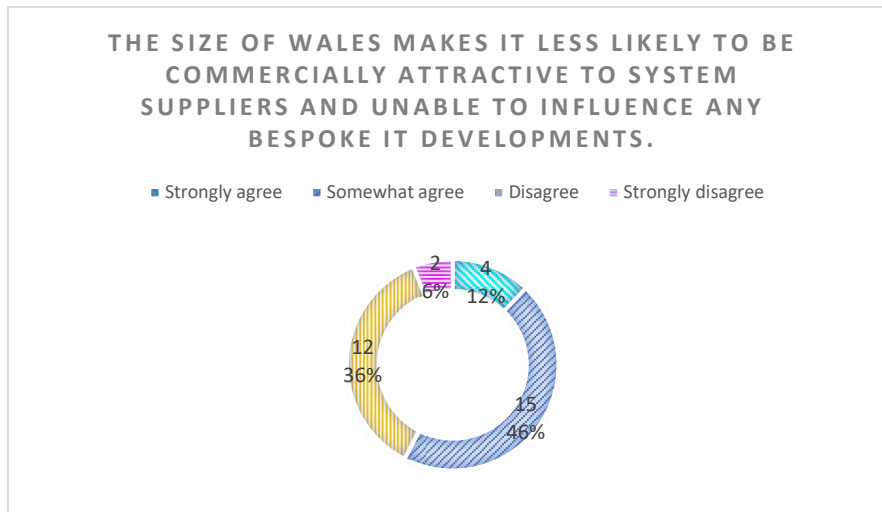


Figure 41. Participant responses to statement 7A Round Two.

Culture of Pharmacy in Wales

For these questions, participants were asked to consider their level of agreement with six statements developed from the first round's responses focusing on the culture of pharmacy in Wales. However, in this round, consensus agreement was not achieved by the panel for any of the statements, thus all were included for review in the third Delphi round. Figure 42 overleaf depicts all the questions and percentage responses received.

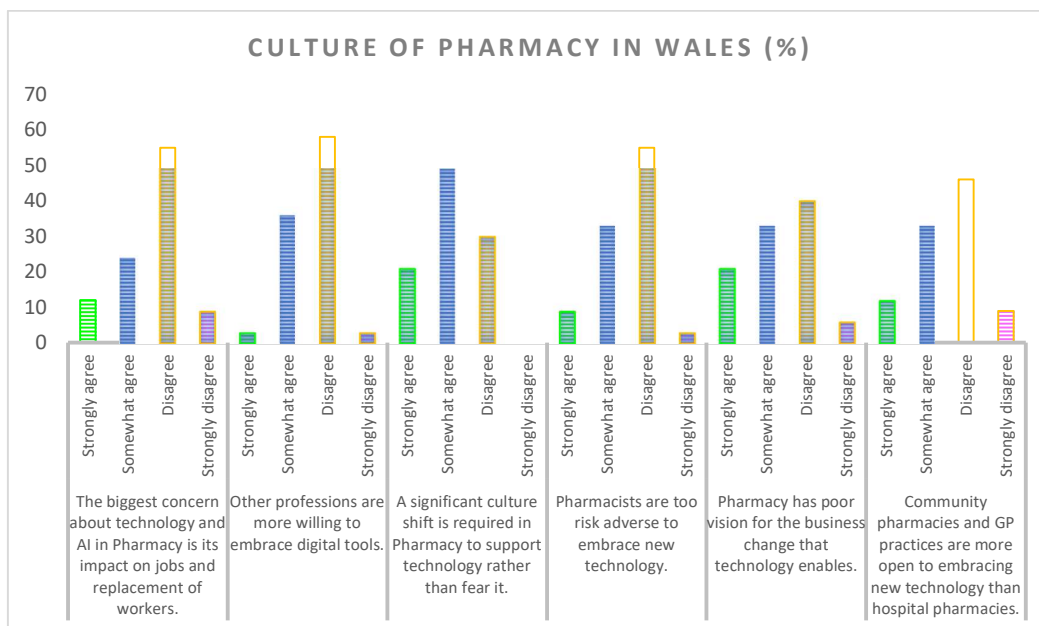


Figure 42. Participant responses to statements in Round Two Question 8 (percentage).

Role Replacement: No Consensus

Consensus was not attained for the initial statement, 'the biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers.' Twelve respondents (36%) agreed and 21 (64%) disagreed, as shown in Figure 43.

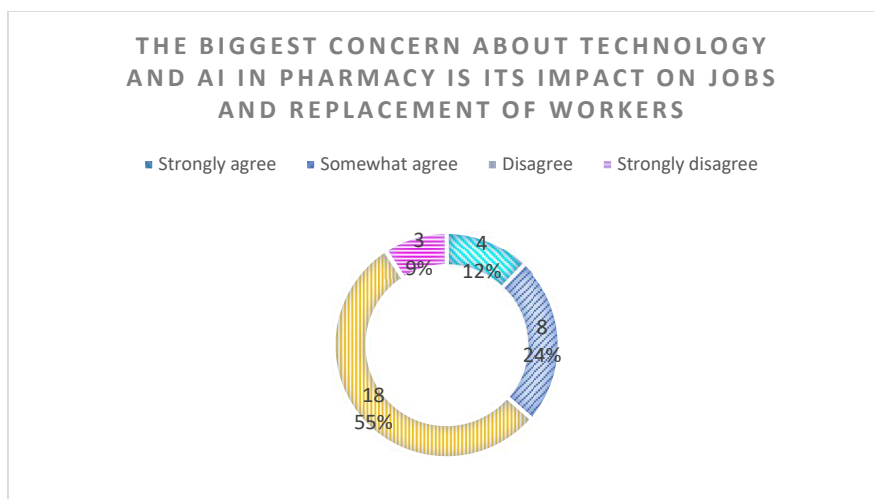


Figure 43. Participant responses to statement 8A Round 2.

Other Professions More Willing to Embrace Digital Tools: No Consensus

Opinion was divided for the second statement: 'Other professions are more willing to embrace digital tools.' Thirteen participants (39%) agreed and 20 (61%) disagreed. This is demonstrated in Figure 44.

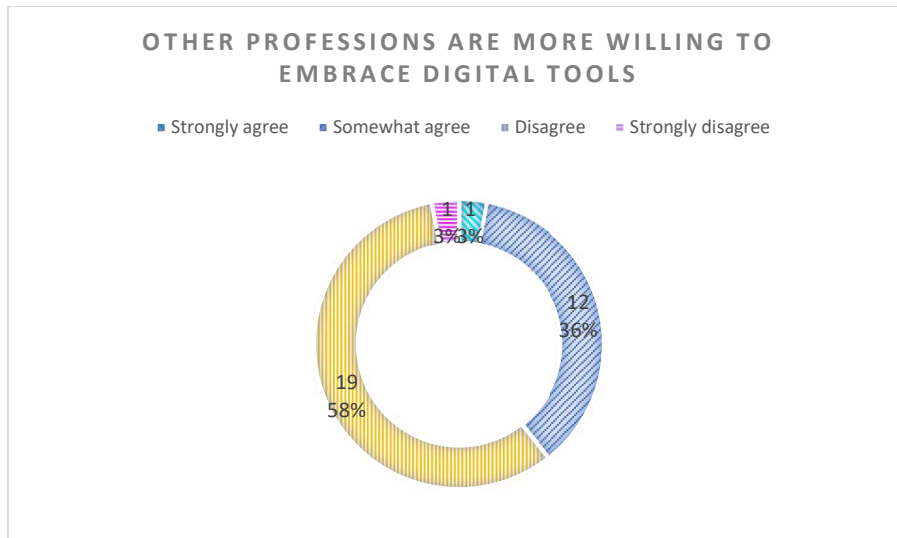


Figure 44. Participant responses to statement 8B Round Two.

Cultural Shift Required: No Consensus

Consensus was nearly achieved by the panel on whether a significant cultural shift is required in pharmacy to support technology rather than fear it. Although 70% (n=23) agreement was obtained, the level of consensus set before conducting the quantitative round was 'greater than 70%,' therefore the statement was included in round three. The breakdown is illustrated in Figure 45 overleaf.

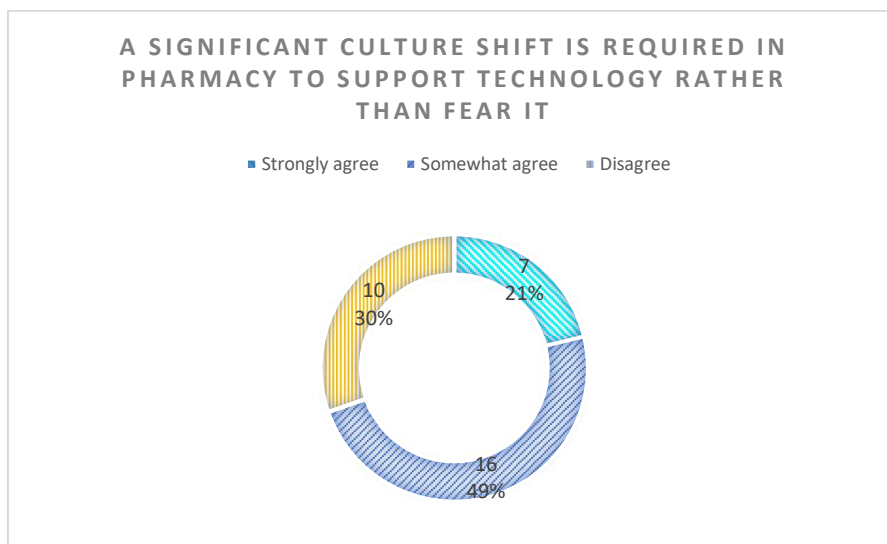


Figure 45. Participant responses to statement 8C Round Two.

Risk Averse: No Consensus

As shown in Figure 46, opinion was split across the panel in round two on Pharmacists being too risk averse to embrace new technology, with 14 (42%) agreeing and 19 (58%) disagreeing with the statement.

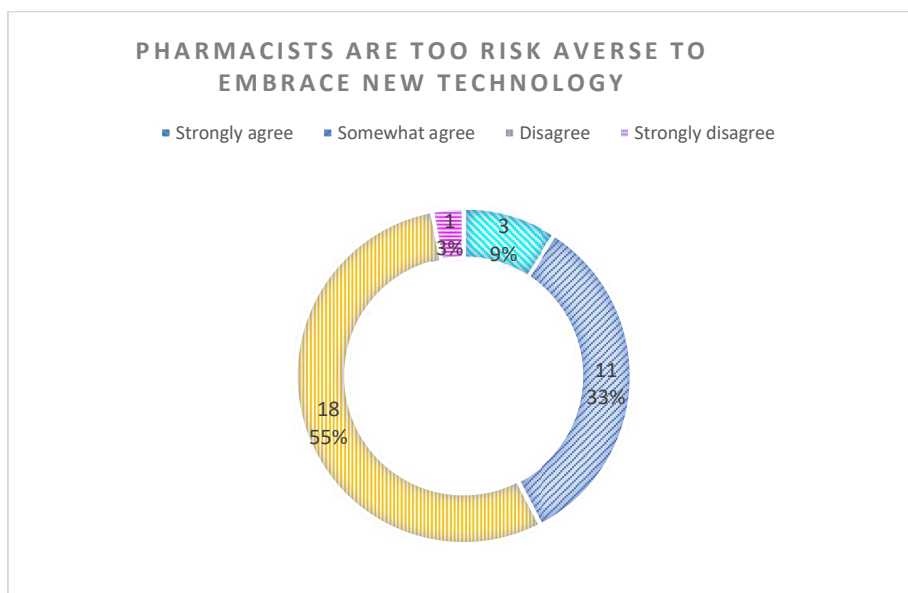


Figure 46. Participant responses to statement 8D Round Two.

Poor Vision for Business Change: No Consensus

Consensus was not reached in this round for the statement ‘pharmacy has poor vision for the business change that technology enables.’ There was a divergence of opinions, with 54% agreeing and 46% disagreeing. This is depicted in Figure 47 below.

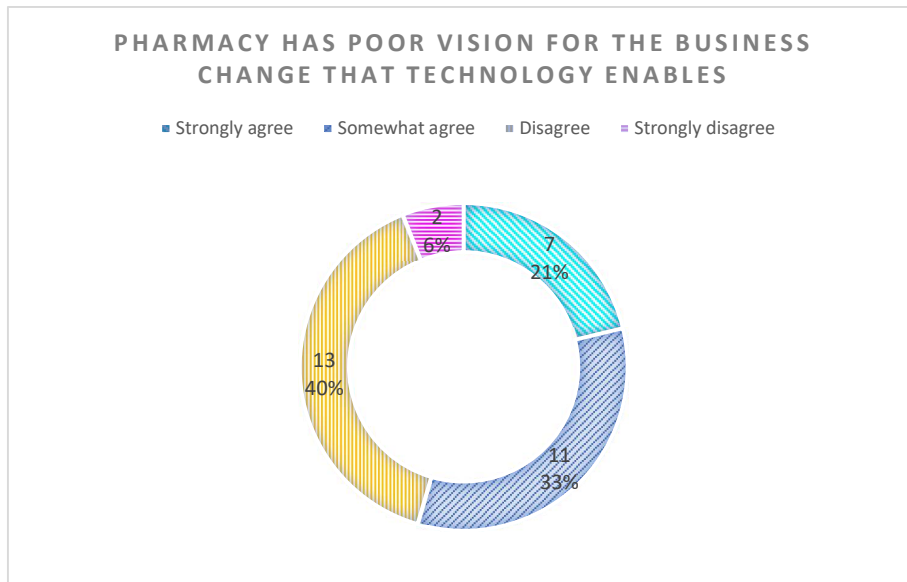


Figure 47. Participant responses to statement 8E Round Two.

Community Pharmacies and GPs Embrace Technology: No Consensus

For the final statement in this section, opinions were divided on whether community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies. Figure 48 overleaf shows that 15 participants agreed with the statement, while 18 (55%) disagreed. As with all the questions in this section, this was reconsidered by the panel in the third round.

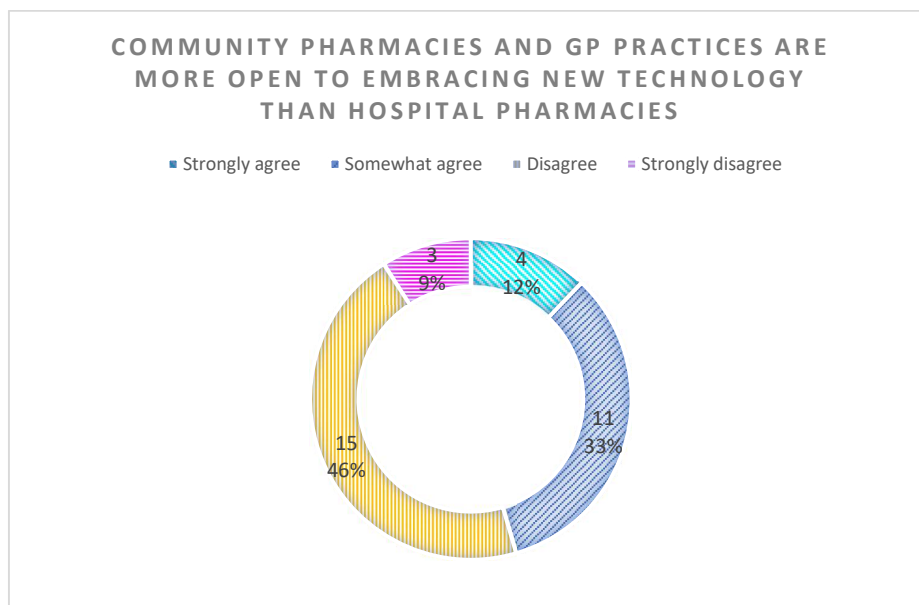


Figure 48. Participant responses to statement 8F Round Two.

Workforce and Skills

The final section of Likert questions comprised of seven statements related to pharmacy workforce and skills. Out of these, six statements reached consensus of over 70% in the second round. One statement was reconsidered in round three. The overview is shown in Figure 49 below.

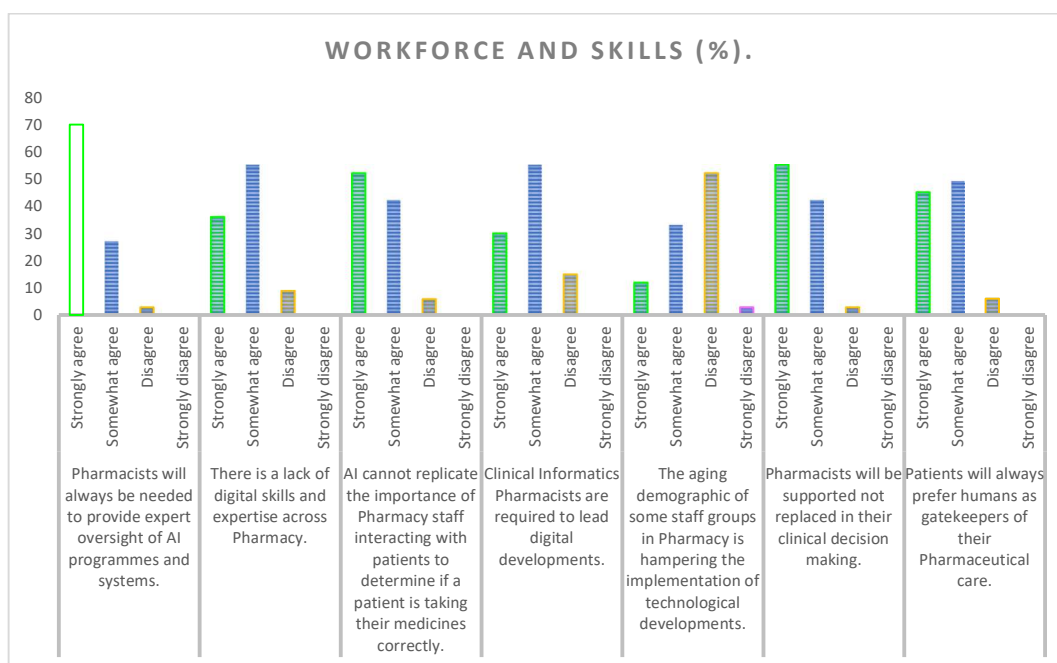


Figure 49. Participant responses to statements in Round Two Question 9 (percentage).

Expert Oversight: Consensus

The first statement in this section sought the panel's opinion on whether 'Pharmacists will always be needed to provide expert oversight of AI programmes and systems.' All but one of the experts agreed with this statement (97%), and 23 of them (70%) selected the 'strongly agree' option. This statement elicited the highest number of extreme responses (i.e., strongly or very) in the survey. This is illustrated in Figure 50.

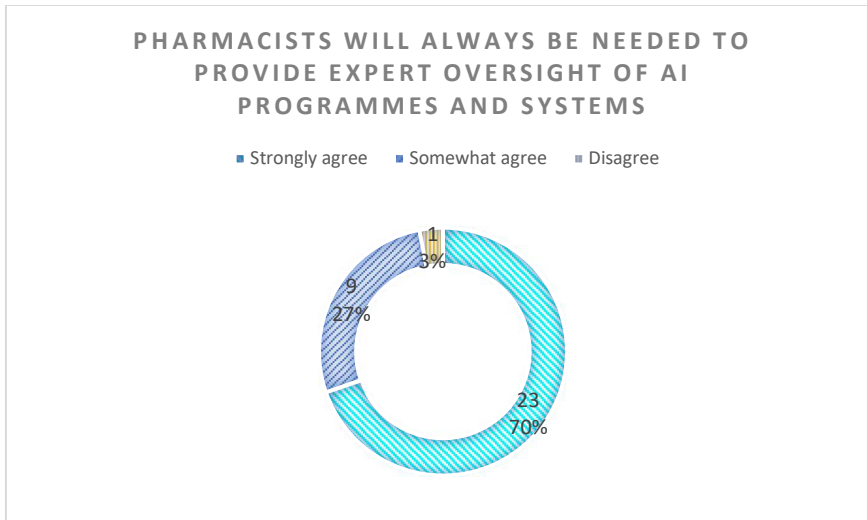


Figure 50. Participant responses to statement 9A Round Two.

Lack of Digital Skills: Consensus

There was a significant level of consensus regarding the second statement that there is a deficiency in digital skills and expertise in the field of pharmacy. As seen in Figure 51 overleaf, in total 91% of the respondents concurred, while only 3 individuals dissented.

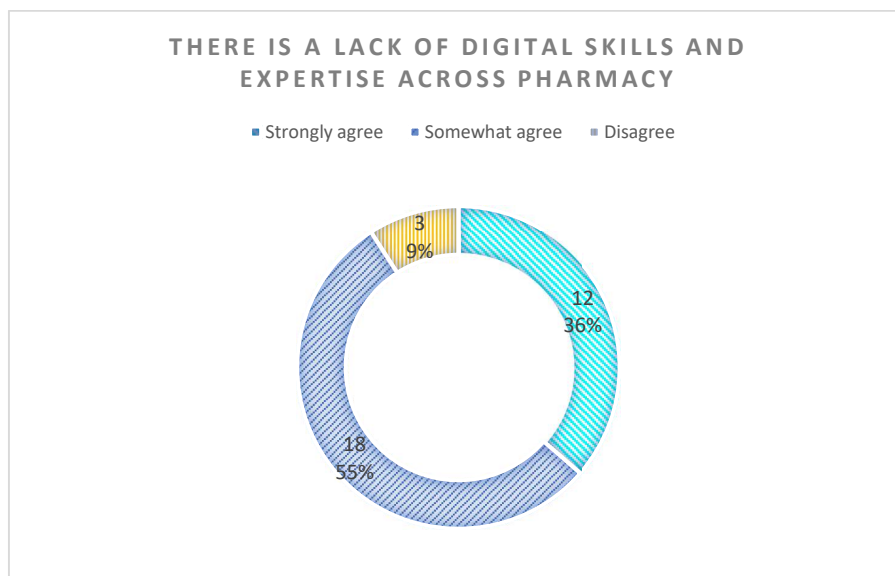


Figure 51. Participant responses to statement 9B Round Two.

Importance of Human Interactions: Consensus

Consensus was also reached for this statement, as 94% of the participants agreed that 'AI cannot replicate the importance of Pharmacy staff interacting with patients to determine if a patient is taking their medicines correctly.' Only two individuals disagreed. This is illustrated in Figure 52.

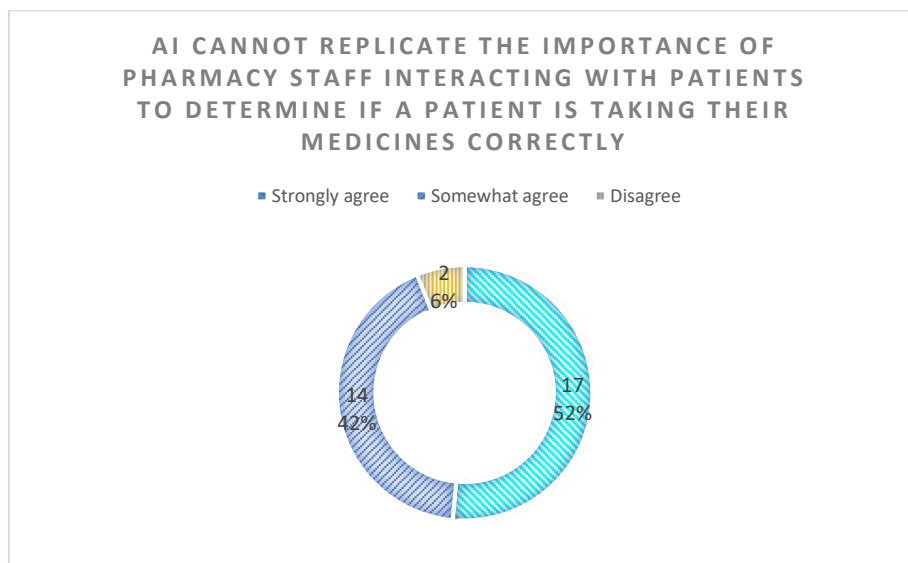


Figure 52. Participant responses to statement 9C Round Two.

Clinical Informatics Pharmacists: Consensus

As demonstrated in Figure 53, the majority of panellists (85% of the total) expressed agreement with the statement that 'Clinical Informatics Pharmacists are required to lead digital developments'. Five individuals among the panel disagreed with this perspective.

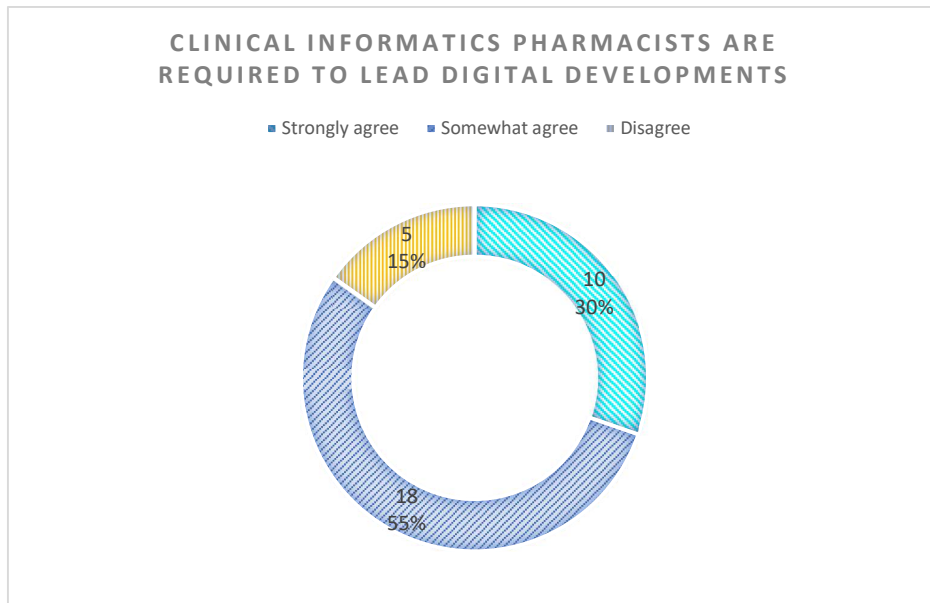


Figure 53. Participant responses to statement 9D Round Two.

AI will Support Clinical Decisions: Consensus

A clear majority of the panel members, amounting to 97% of respondents, expressed their agreement with the statement that pharmacists would be supported rather than replaced in their clinical decision making. Of the total participants, 18 (55%) strongly agreed with the statement, while only one individual disagreed. This is illustrated in Figure 54 overleaf.

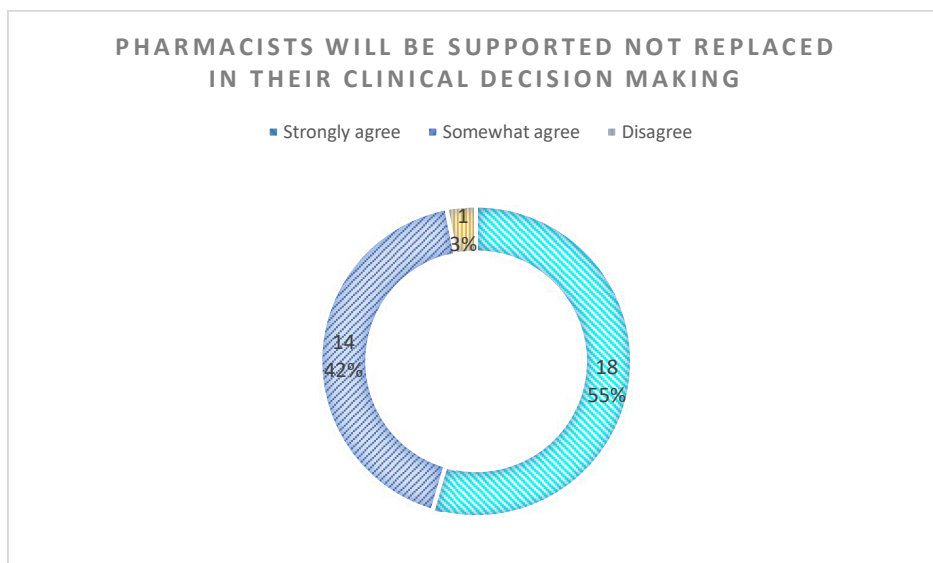


Figure 54. Participant responses to statement 9F Round Two.

Patient Preference: Consensus

The final statement in this section stated that patients will always prefer humans as gatekeepers of their pharmaceutical care. Figure 55 shows there was a strong consensus of opinion, with 31 participants (94%) agreeing and of those, 15 (45%) selected 'strongly agree'.

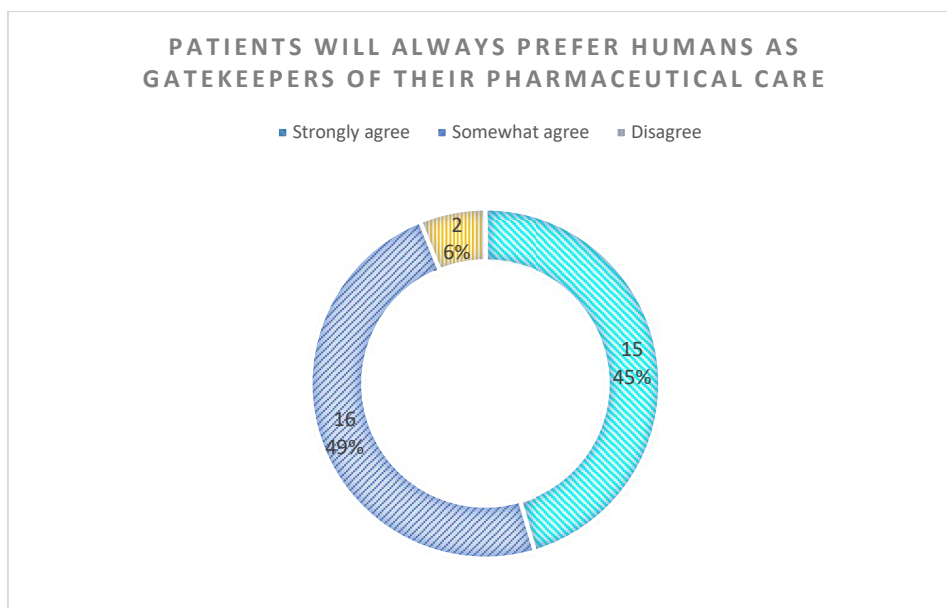


Figure 55. Participant responses to statement 9F Round Two.

Barrier of Ageing Staff: No Consensus

As illustrated in Figure 56, opinion was split in Round Two for the statement 'the aging demographic of some staff groups in Pharmacy is hampering the implementation of

technological developments.’ Fifteen individuals (45%) agreed with the statement, while eighteen (55%) disagreed. This was subsequently added to Round Three questions.

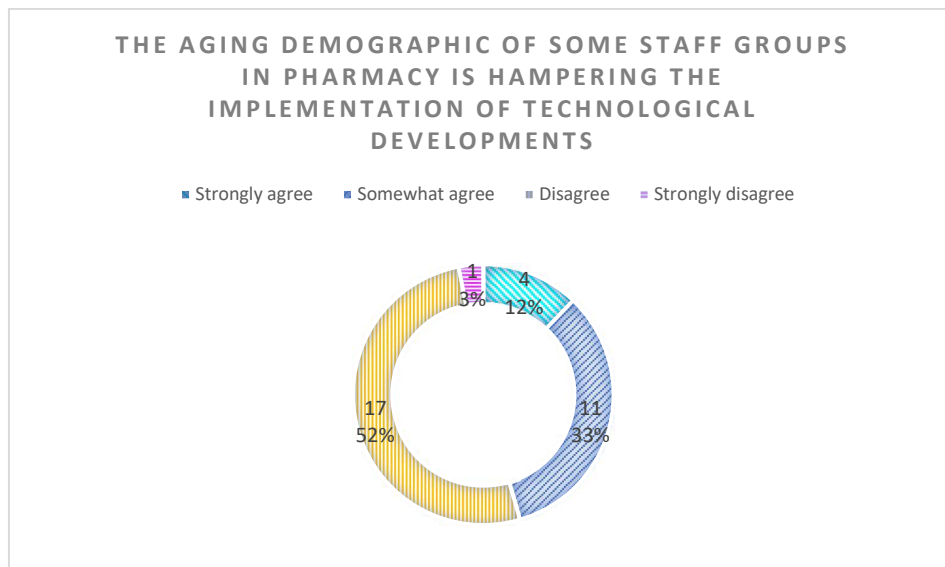


Figure 56. Participant responses to statement 9E Round Two.

4.4.2 Ranking Questions- Round Two

Two ranking questions were used to determine the panel’s development priorities for pharmacy in the future. These were constructed from the participants’ suggestions in the first Delphi round. They were again split into ‘digital technology and automation’ and ‘artificial intelligence and machine learning technology’, although on reflection there may been some cross-over in the descriptions.

Priority for utilisation of digital technology and automation in pharmacy by the year 2050.

The expert panellists were asked to rank what they thought personally would be the most beneficial development in digital technology and automation for pharmacy by 2050. Figure 17 overleaf shows the percentage ranking chosen by the participants for each statement (rank 1-4, where rank 1 is the highest priority). In this round ‘A fully integrated digital health record accessed across all NHS organisations’ was found to be the highest priority. The same questions were repeated in round three to test the stability of opinion.

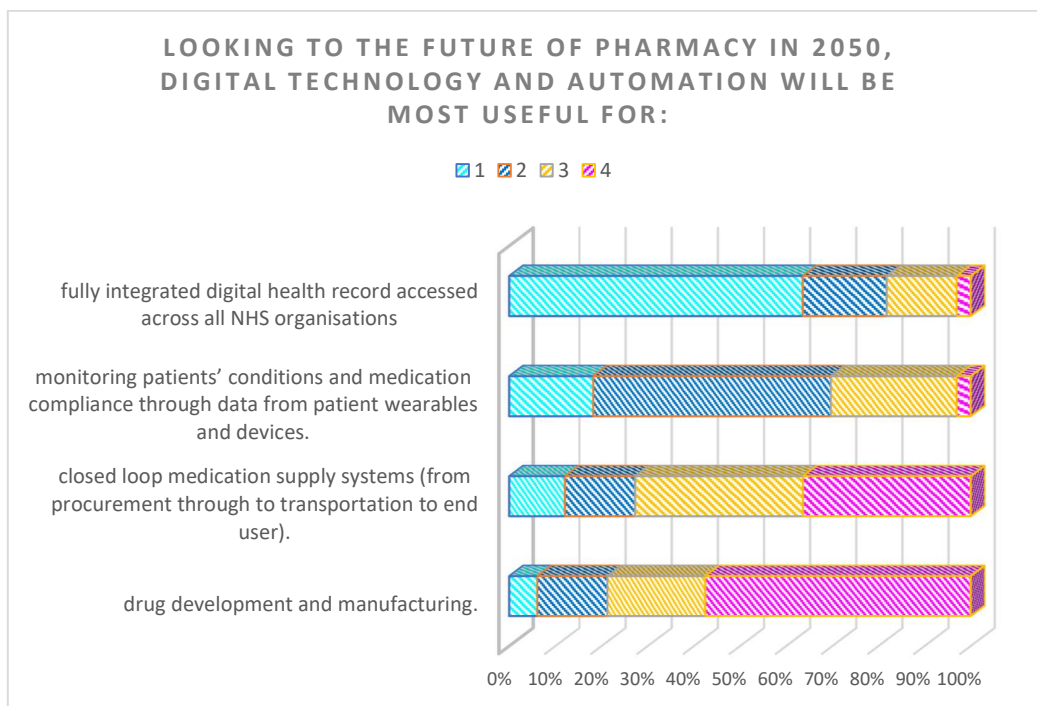


Figure 57. Stacked bar graph of % participant ranking for Round Two Question 3, where Rank 1= highest priority.

Priority for utilisation of artificial intelligence and machine learning in pharmacy by the year 2050.

This question required participants to rank what they thought would be the most beneficial developments in AI and ML for pharmacy by 2050. The bar graphs in Figure 58 illustrate the percentage ranking chosen by the participants for each statement (rank 1-6, where rank 1 is the highest priority). In round two 'full genomic profiling to guide optimum prescribing and generate individualised treatment plans' was the highest ranked priority by the panel.

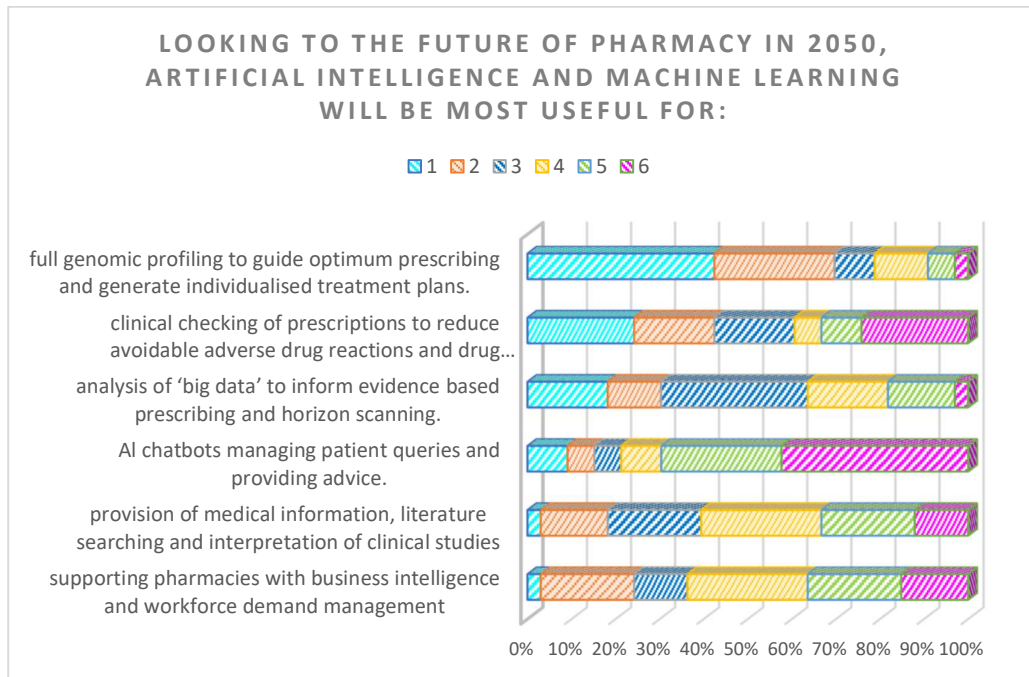


Figure 58. Stacked bar graph of % participant ranking for Round Two Question 4, where Rank 1= highest priority.

4.4.3 Summary

In the second round, 26 of the 39 Likert questions achieved consensus of over 70% convergence of expert opinion. These were subsequently excluded from the final round of the Delphi study. For the priority ranking questions, the same statements and format were repeated in the third round to assess the stability of opinion. The cumulative percentage of instances where the option was selected as a first or second 'high priority' ranking in this round was included in the questions as feedback to the participants.

4.5 DELPHI ROUND THREE

The third round followed the same format as round two, however the length of the questionnaire was reduced as any Likert questions that reached over 70% expert agreement were not revisited in this round. The priority ranking questions were presented back to the panel in full to test stability of response.

4.5.1 Likert Scale Questions- Round Three

The 13 Likert questions that did not achieve consensus were revisited by the panel in the final round, to test if the target of over 70% cumulative agreement or disagreement with the statements could be reached. The percentage of agreement for each of the options in the previous round was included as feedback for the panel. As previously, SSPS was used to calculate the mean score of the responses to determine the level of significance the panel deemed each statement.

Predictions on the use of Digital Technology, Automation and AI in Pharmacy by 2030

From these first two sections only one of the statements concerning the accuracy checking of dispensed medication did not reach over 70% consensus agreement by the panel in the second round.

Accuracy Checking of Dispensed Medication: No Consensus

When this statement was reconsidered in round three, there was a marginal swing of opinion from 55% thinking this development was unlikely by 2030 to 56% now thinking it was likely. However, a consensus was not achieved. This is illustrated in Figure 59 overleaf.

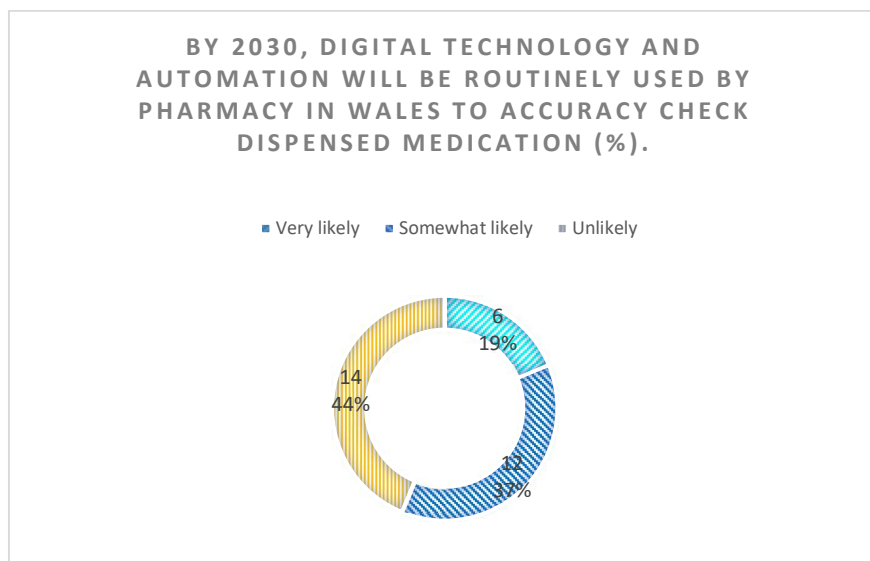


Figure 59. Participant responses to statement 1C Round Three.

Level of Importance of the Statements

Consensus was defined prior to commencing the study as the cumulative agreement or disagreement of over 70% with the statements through the two subsequent Delphi rounds. As discussed in the methodology chapter, the calculation of the mean of the responses in SSPS (where 1= Very likely, 2= Somewhat likely, 3= Unlikely, 4= Very unlikely) determined the level of importance of the statement compared to the others rated in the rounds of the Delphi process. Table 14 illustrates the most important statement in this section was the panel's consensus agreement that by 2030, digital technology and automation will provide pharmacy in Wales with the ability to share or transfer patient medication data between healthcare providers. The second highest rated statement was that technology will be employed for medicines procurement and invoicing by 2030.

Table 14. Likert statements relating to 2030 predictions for technology & automation ranked by mean level of importance.

By 2030, digital technology and automation will be routinely used by Pharmacy in Wales...		Mean	Consensus level
1D	to share or transfer patient medication data between healthcare providers.	1.42	94
1B	for medicines procurement and invoicing.	1.61	94
1A	to dispense prescriptions.	1.64	88
1F	no more than the current situation.	*(3.33)	(91)
1E	to supply medicines through automated cabinets across sectors.	2.03	73
1C	to accuracy check dispensed medication.	-	-

*consensus of negative opinion

Table 15 below indicates that the most significant statement for the anticipated utilisation of AI and ML by 2030 to aid the development, delivery and assessments for education and training in pharmacy. The second most important statement according to the panel is the probable deployment of AI and ML to offer medication information to other healthcare professionals.

Table 15. Likert statements relating to 2030 predictions for AI & ML ranked by mean level of importance.

By 2030, artificial intelligence and machine learning technology will be routinely used by Pharmacy in Wales...		Mean	Consensus level
2C	to aid development, delivery and assessments for education and training.	1.79	85
2D	to provide medicines information to other health professionals.	1.82	88
2B	to provide patient advice and counselling through chat function assistants.	1.85	82
2E	no more than the current situation.	*(3.12)	(79)
2A	to assist Pharmacists when clinically checking prescriptions.	1.97	79

*consensus of negative opinion

Digital Infrastructure in Wales

From this set of Likert questions describing opinions about digital infrastructure in Wales, only one statement did not reach consensus in the second round.

Transparency and trust in past projects: consensus

As the question only reached 69% consensus of agreement in round two, it was reconsidered in round three. Consensus was now reached with 78% (n=25) agreeing with the statement, as seen in Figure 60.

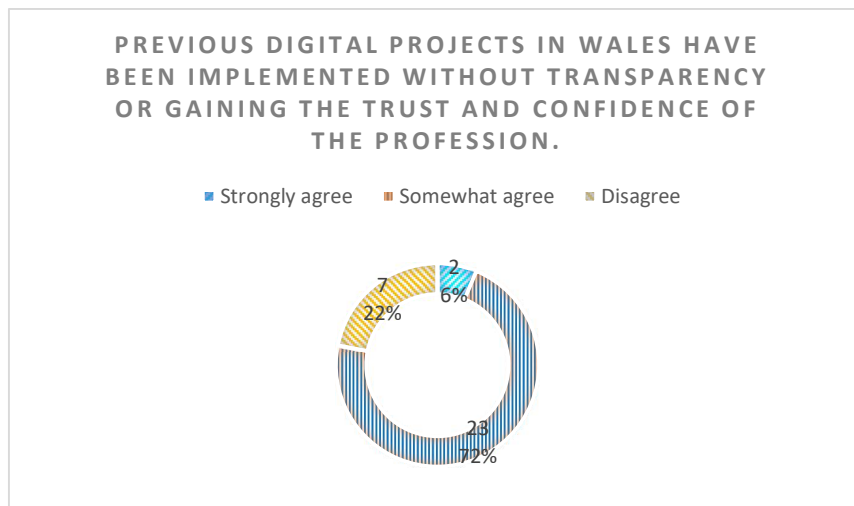


Figure 60. Participant responses to statement 5D Round Three.

Level of Importance of the Statements

Although all statements relating to digital infrastructure in Wales reached consensus, the significance of each statement was evaluated by comparing its mean score against those of the other statements pertaining to digital infrastructure in Wales. Numerical values were assigned to the responses for this question (and the following questions) to facilitate descriptive analysis and mean value calculations using SSPS. Responses were scored on a scale of 1 to 4, with 1 indicating strong agreement and 4 indicating strong disagreement.

Table 16 below illustrates that the most highly rated statement in this section was concerned with the challenges faced when implementing digital pilot projects due to their inability to integrate and interface with broader systems. The second-highest rated statement by the panel was that NHS Wales should adopt a 'Once for Wales' approach for scoping, tendering, procurement and deployment of technology to ensure system standardisation and interoperability.

Table 16. Likert statements relating to digital infrastructure in Wales ranked by mean level of importance.

Digital infrastructure in Wales		Mean	Consensus level
5C	A significant challenge to rolling out pilot digital projects is the inability to integration and interface with wider systems.	1.48	97
5E	NHS Wales should follow a Once for Wales approach for scoping, tendering, procurement and deployment of technology to ensure systems standardisation and interoperability.	1.52	91
5B	A reliance on DHCW being the third-party organisation to provide support and expertise to implement technology hinders development and increases costs.	1.97	79
5A	NHS Wales has the advantage of a nationally managed digital infrastructure.	2.09	82
5D	Previous digital projects in Wales have been implemented without transparency or gaining the trust and confidence of the profession.	2.16	78

Strategy in Wales

In the second round, three statements did not reach consensus so were included in round three. Subsequently, only one of these reached over 70% agreement in this final round.

Strong Pharmacy Leadership: Consensus

Although the majority of respondents (67%) agreed in round two that 'There is strong leadership in Pharmacy in Wales, allowing us work effectively as a single entity in the way we embrace and progress technology,' this did not reach the target consensus. However, in this round consensus was reached with 84% (n=27) agreeing with the statement. This is shown in Figure 61 overleaf.

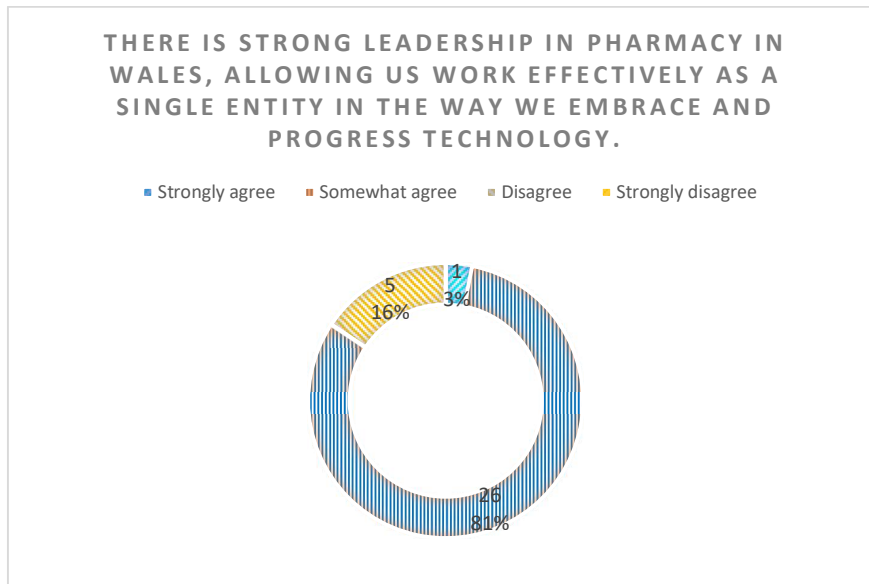


Figure 61. Participant responses to statement 6D Round Three.

Flexible and Agile Approach: No Consensus

When this statement ‘Wales takes a flexible and agile approach to implementation and adoption of new technologies’ was considered in round two, consensus was not achieved although the majority 61% disagreed. When it was reviewed in round three, opinion diverged further with 15 agreeing (47%) and 17 (53%) disagreeing, although both extremes of ‘strong’ opinions were not chosen. This is depicted in Figure 62.

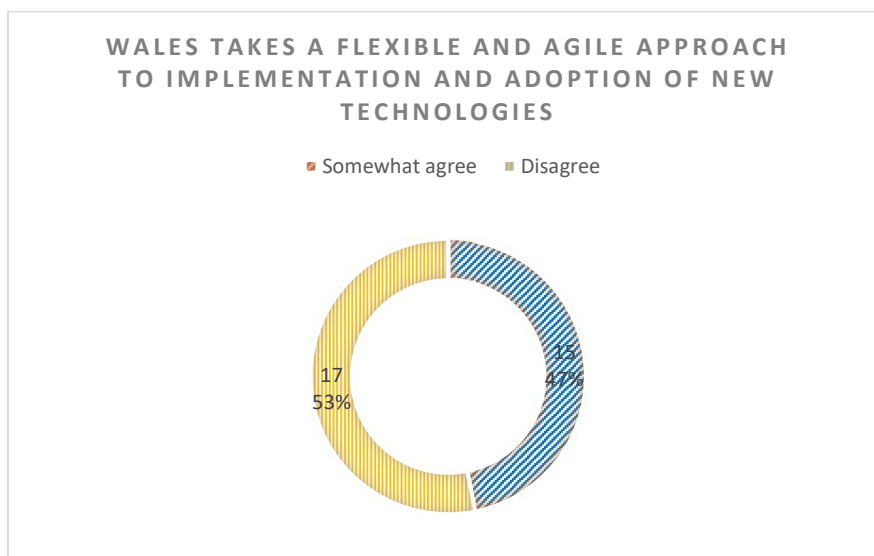


Figure 62. Participant responses to statement 6C Round Three.

Acting 'Once for Wales' is a Barrier: No Consensus

Again, the statement 'Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology,' did not reach consensus when reconsider. As illustrated in Figure 63, opinion remained split with the same number agreeing (12) and 20 disagreeing, although less strongly disagreed (2) compared to the previous round.

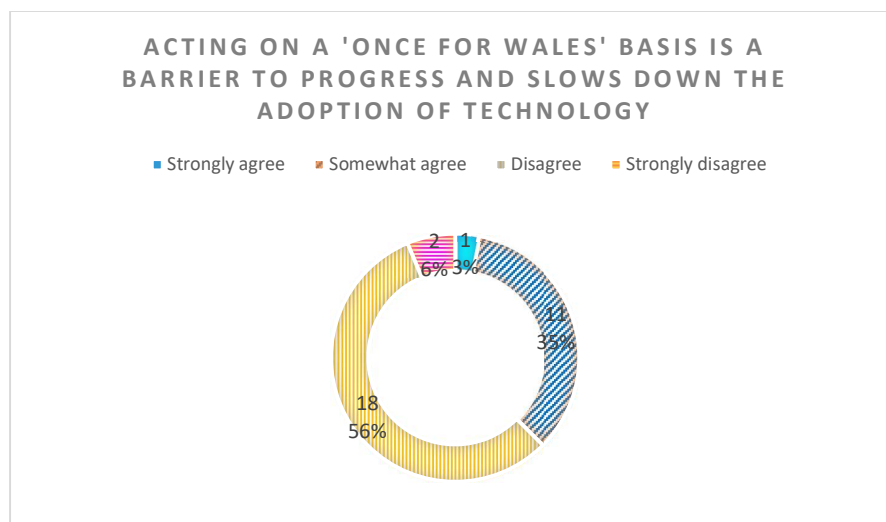


Figure 63. Participant responses to statement 6E Round Three.

Level of Importance of the Statements

Table 17 highlights the most highly ranked statement that achieved consensus in response in this section referred to the benefits a coherent national strategy in PDaHW, as a means of promoting digital change.

Table 17. Likert statements relating to strategy in Wales ranked by mean level of importance.

Q6: Strategy in Wales		Mean	Consensus level
6B	A coherent national strategy in PDaHW which includes the digital ambition for the profession, is a useful tool to support change.	1.88	94
6D	There is strong leadership in Pharmacy in Wales, allowing us work effectively as a single entity in the way we embrace and progress technology.	2.13	84
6A	In NHS Wales decision-making is streamlined and there are less hurdles in respect to governance for digital projects.	*(2.82)	*(73)
6C	Wales works in a flexible and agile approach to implementation and adoption of new technologies.	-	-
6E	Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology.	-	-

*consensus of negative opinion

Characteristics of Wales

In this section, only one of the five statements regarding the characteristics of Wales in terms of healthcare and pharmacy, did not reach consensus in round two.

Too Small Commercially: Consensus

Opinion was split on whether ‘the size of Wales makes it less likely to be commercially attractive to system suppliers and unable to influence any bespoke IT developments,’ with a small majority (58%) of participants agreeing with the statement. In the third round, consensus was reached with 75% (21) agreement. The ‘strongly disagreed’ option was not chosen. This is illustrated in Figure 64.

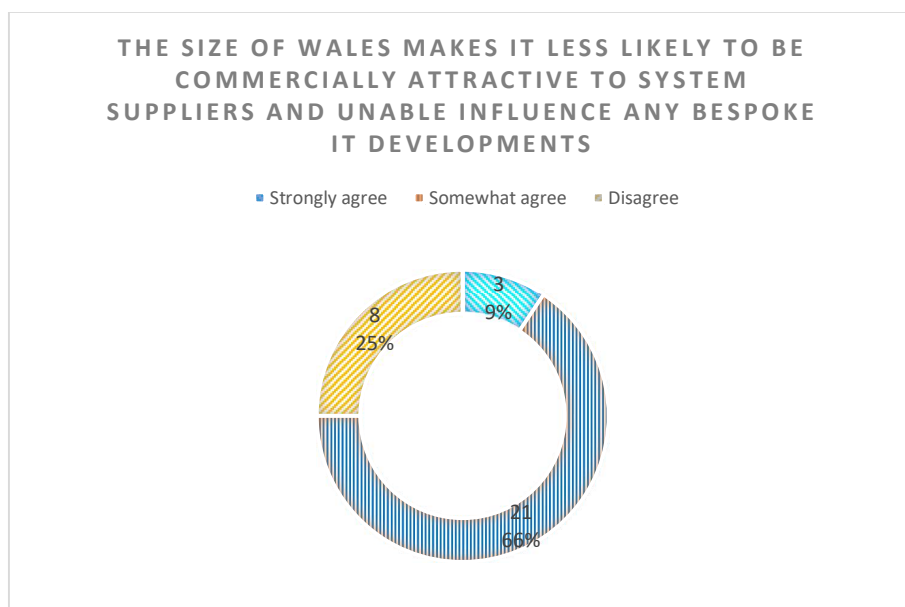


Figure 64. Participant responses to statement 7A Round Three.

Level of Importance of the Statements

According to the data depicted in Table 18 below, the most highly rated statement in Question 7 was ‘the size of Wales allows us to trial advances in technology and scale up good practice rapidly.’ However, the panel also acknowledged the existence of were significant funding challenges for digital development, which they ranked as the second most important statement.

Table 18. Likert statements relating to Characteristics of Wales ranked by mean level of importance.

Q7: Characteristics of Wales		Mean	Consensus level
7C	The size of Wales allows us to trial advances in technology and scale up good practice rapidly.	1.73	94
7B	There are significant challenges funding digital developments in Wales.	1.76	97
7D	Developments to improving access to remote healthcare and medicines supply in sparsely populated rural areas should be a priority for Pharmacy in Wales.	1.85	79
7E	As a small country, Wales is able to co-ordinate and implement wide spread change through established networks and a limited number of organisations	2.03	73
7A	The size of Wales makes it less likely to be commercially attractive to system suppliers and unable influence any bespoke IT developments.	2.16	75

Culture of Pharmacy in Wales

All of the six statements included in this section did not reach greater than 70% consensus in round two and only two reached consensus agreements by the panel in the third round.

Role Replacement: Consensus Disagreement

In the previous round the majority (64%) of the participants disagreed with the statement that ‘the biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers,’ although consensus was not reached. When the question was considered in round three, a consensus was reached with 75% (n=24) of participants disagreeing with the statement. This is shown in Figure 65.

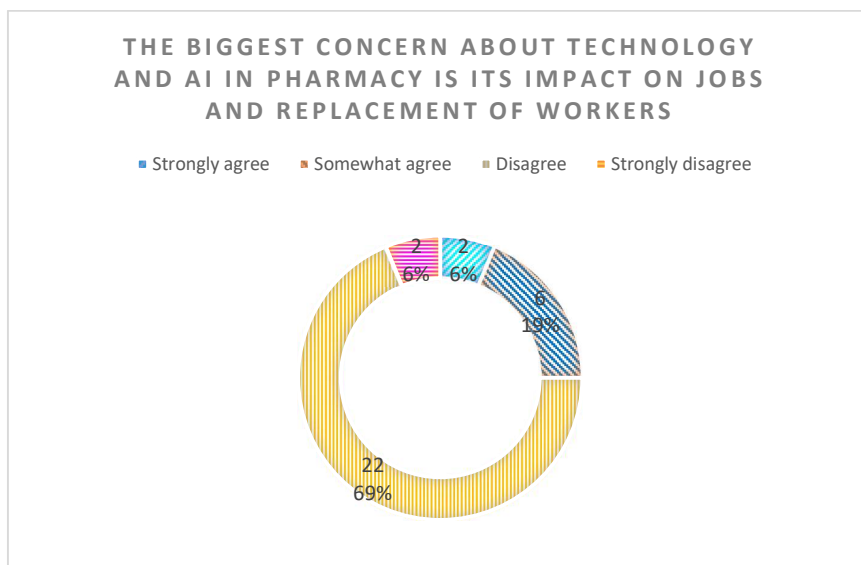


Figure 65. Participant responses to statement 8A Round Three.

Cultural Shift Required: Consensus

Although a large majority of the (70%) agreed initially that a significant cultural shift is required in pharmacy to support technology rather than fear it, the consensus target of over 70% was not met. In round three, consensus was reached with 88% (28) agreement, as shown in Figure 66. This statement had the highest percentage consensus achieved in round three.

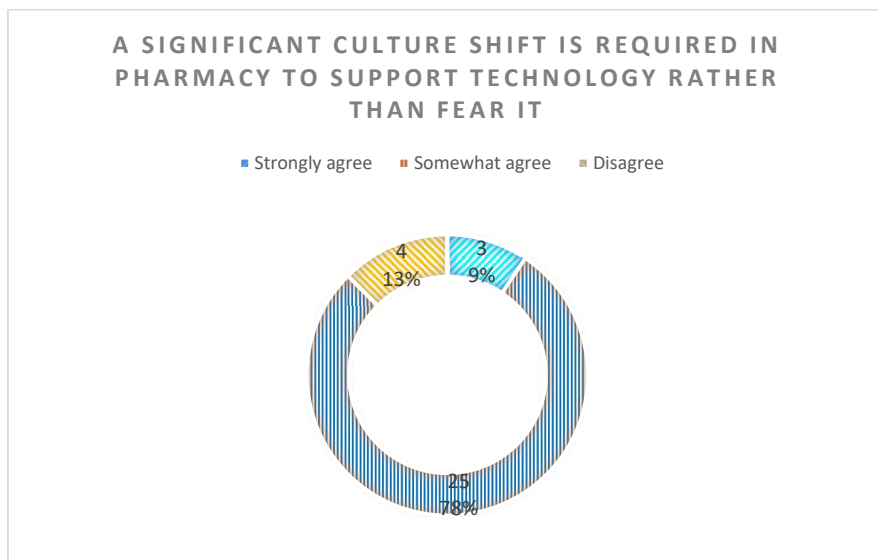


Figure 66. Participant responses to statement 8C Round Three.

Other Professions More Willing to Embrace Digital Tools: No Consensus

In the previous round, the majority of respondents (61%) disagreed that ‘Other professions are more willing to embrace digital tools.’ When the statement was reconsidered in round three, consensus was almost achieved with 22 (69%) disagreeing with the opinion, although both extremes of ‘strong’ opinions were not selected in this round. This is depicted in Figure 67.

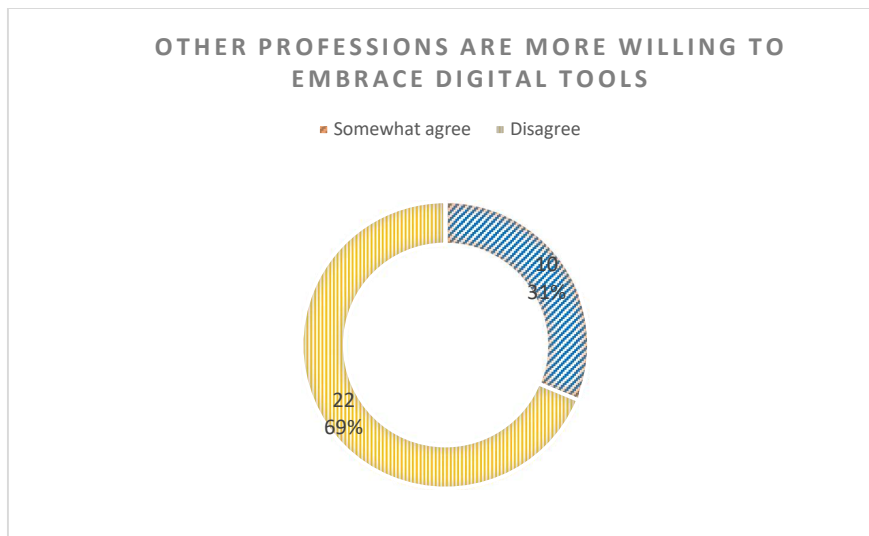


Figure 67. Participant responses to statement 8B Round Three.

Risk Averse: No Consensus

Opinion was split across the panel in round two on Pharmacists being too risk averse to embrace new technology, with 58% disagreeing with the statement. In round three, consensus was still not reached with the same number of participants (19) disagreeing with the statement. This is illustrated in Figure 68.

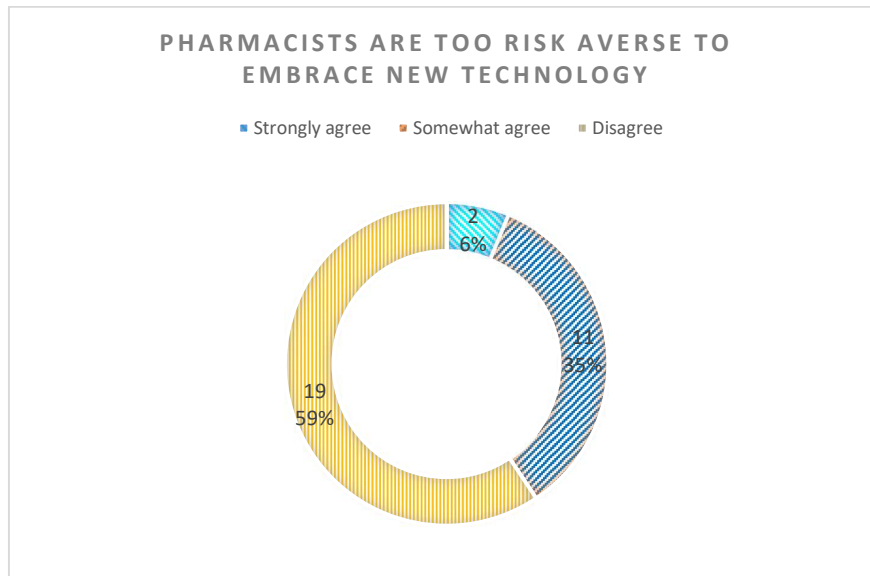


Figure 68. Participant responses to statement 8D Round Three.

Poor Vision for Business Change: No Consensus

In round two, opinion was split for the statement ‘pharmacy has poor vision for the business change that technology enables,’ with 54% agreeing with the statement (n=18). When reviewed in round three, consensus was not achieved. As seen in Figure 69, more participants (n= 19, 59%) disagreed, although more strongly agreed (10%) than strongly disagreed (3%).

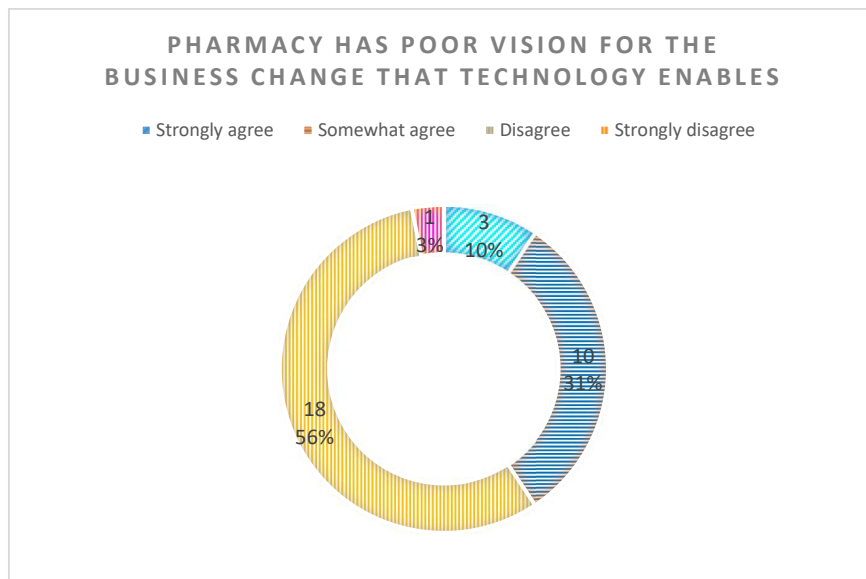


Figure 69. Participant responses to statement 8E Round Three.

Community Pharmacies and GPs Embrace Technology: No Consensus

In the previous round, opinions were divided on whether community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies, with 55% disagreeing with the statement. Consensus was still not recached in round three, although a larger majority (66%) disagreed with statement. This is shown in Figure 70.

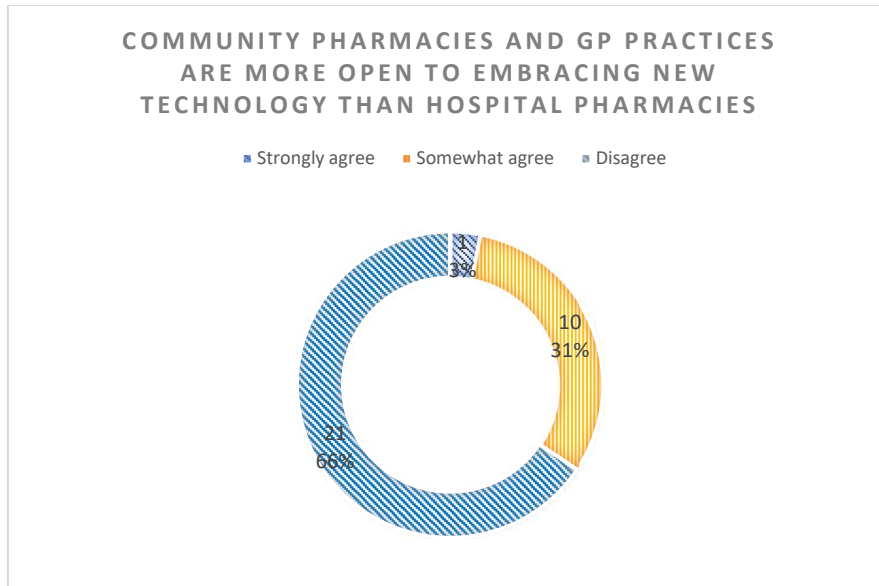


Figure 70. Participant responses to statement 8F Round Three.

Level of Importance of the Statements

In this section there were only two statements that gained consensus. Moreover, the degree of importance accorded to both was not particularly high when compared to other sections, as demonstrated in Table 19 overleaf.

Table 19. Likert statements relating to Culture of Pharmacy in Wales ranked by mean level of importance.

Q8: Culture of Pharmacy in Wales		Mean	Consensus level
8C	A significant culture shift is required in Pharmacy to support technology rather than fear it.	2.03	88
8A	The biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers.	*(2.75)	*(75)
8B	Other professions are more willing to embrace digital tools.	-	-
8D	Pharmacists are too risk averse to embrace new technology.	-	-
8E	Pharmacy has poor vision for the business change that technology enables.	-	--
8F	Community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies.	-	-

**consensus of negative opinion*

Workforce and Skills

In the final section looking at views about pharmacy workforce and skills, only one of the six statements did not reach consensus of over 70% in the second round.

Barrier of Aging Staff: No Consensus

In round two, 55% of the panellists expressed disagreement with statement ‘the aging demographic of some staff groups in Pharmacy is hampering the implementation of technological developments.’ This increased to 63% in round three, but consensus was not reached. This is shown in Figure 71.

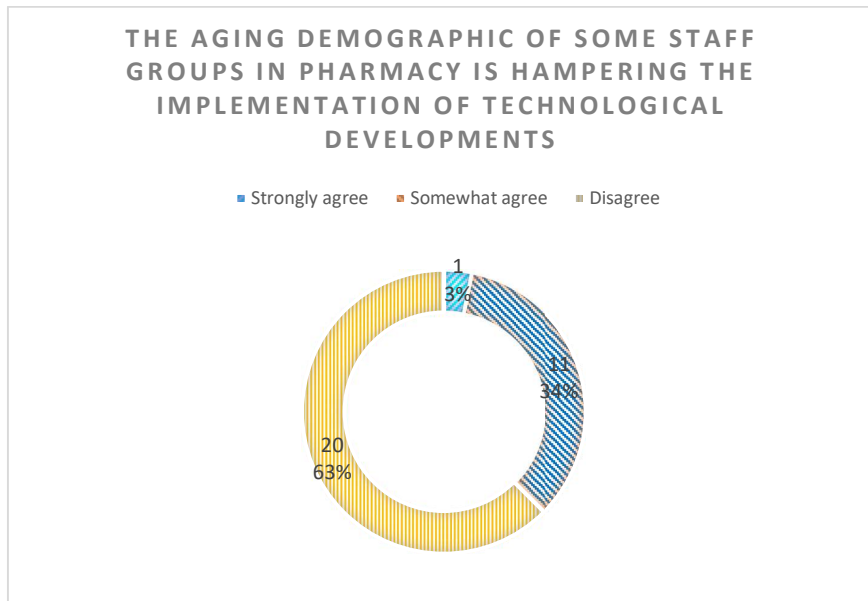


Figure 71. Participant responses to statement 9E Round Three.

Level of Importance of the Statements

The data presented in the Table 20 indicates the most highly rated statement about pharmacy workforce and skills is the positive agreement by the panel that Pharmacists will always be needed to provide expert oversight of AI programmes and systems. The second most significant statement referenced by the panel was the belief that pharmacists will be aided by AI when making clinical decisions rather than being replaced. Nevertheless, all the other statements that gained consensus in this section were ranked highly (scoring less than 2) by the panel.

Table 20. Likert statements relating to workforce and skills ranked by mean level of importance.

Q9: Workforce and skills		Mean	Consensus level
9A	Pharmacists will always be needed to provide expert oversight of AI programmes and systems	1.33	97
9F	Pharmacists will be supported not replaced in their clinical decision making.	1.48	97
9C	AI cannot replicate the importance of Pharmacy staff interacting with patients to determine if a patient is taking their medicines correctly.	1.55	94
9G	Patients will always prefer humans as gatekeepers of their pharmaceutical care.	1.61	94
9B	There is a lack of digital skills and expertise across Pharmacy.	1.73	91
9D	Clinical Informatics Pharmacists are required to lead digital developments.	1.85	85
9E	<i>The aging demographic of some staff groups in Pharmacy is hampering the implementation of technological developments.</i>	-	-

Comparison of all Likert Questions

Table 21 illustrates the Likert statements that attained the highest degree of consensus agreement during the second and third rounds of the Delphi process. Four statements achieved a noteworthy 97% consensus, with only one respondent expressing a differing opinion for each question. These included statements relating to the challenges of funding and rolling out digital developments, as well as the necessity for pharmacists to oversee AI systems and continue making clinical decisions in the future. A further six statements received 94% consensus, with only two panel members dissenting in these instances.

Table 21. Top ten Likert statements achieving the highest percentage consensus.

Likert statement		Mean	Consensus level (%)
5C	Digital infrastructure in Wales- A significant challenge to rolling out pilot digital projects is the inability to integration and interface with wider systems.	1.48	97
7B	Characteristics of Wales- There are significant challenges funding digital developments in Wales.	1.76	97
9A	Workforce and skills- Pharmacists will always be needed to provide expert oversight of AI programmes and systems.	1.33	97
9F	Workforce and skills- Pharmacists will be supported not replaced in their clinical decision making.	1.48	97
1B	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales for medicines procurement and invoicing.	1.61	94
1D	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales to share or transfer patient medication data between healthcare providers.	1.42	94
6B	Strategy in Wales- A coherent national strategy in PDaHW which includes the digital ambition for the profession, is a useful tool to support change.	1.88	94
7C	Characteristics of Wales- The size of Wales allows us to trial advances in technology and scale up good practice rapidly.	1.76	94
9C	Workforce and skills- AI cannot replicate the importance of Pharmacy staff interacting with patients to determine if a patient is taking their medicines correctly.	1.61	94
9G	Workforce and skills- Patients will always prefer humans as gatekeepers of their pharmaceutical care.	1.55	94

Table 22 presents the panel's collective view on the importance of each statement within the Likert questions in a different order, where the lowest mean score corresponds to the most significant statement for the panel. This reveals that the most important statement overall for the panel was the view that pharmacists will play a vital role in supporting artificial intelligence programs and systems by utilising their expert knowledge.

Table 22. Top ten Likert statements achieving the highest level of importance (lowest mean rating of agreement).

Likert statement		Mean	Consensus level (%)
9A	Workforce and skills- Pharmacists will always be needed to provide expert oversight of AI programmes and systems.	1.33	97
1D	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales to share or transfer patient medication data between healthcare providers.	1.42	94
5C	Digital infrastructure in Wales- A significant challenge to rolling out pilot digital projects is the inability to integration and interface with wider systems.	1.48	97
9F	Workforce and skills- Pharmacists will be supported not replaced in their clinical decision making.	1.48	97
5E	Digital infrastructure in Wales- Wales should follow a Once for Wales approach for scoping, tendering, procurement & deployment of technology to ensure systems standardisation and interoperability.	1.52	91
9C	Workforce and skills- AI cannot replicate the importance of Pharmacy staff interacting with patients to determine if a patient is taking their medicines correctly.	1.55	94
1B	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales for medicines procurement and invoicing.	1.61	94
9G	Workforce and skills- Patients will always prefer humans as gatekeepers of their pharmaceutical care.	1.61	94
1A	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales to dispense prescriptions.	1.64	88
7C	Characteristics of Wales- The size of Wales allows us to trial advances in technology and scale up good practice rapidly.	1.73	94
9B	Workforce and skills- There is a lack of digital skills and expertise across Pharmacy.	1.73	91

Statements that Did Not Reach Consensus

There were eight statements that failed to achieve panel consensus in the study. These were mainly relating to the theme of 'Culture of Pharmacy in Wales' in the study, as depicted in Table 23.

Table 23. Likert statements that did not reach consensus.

Likert statement	
1C	By 2030, digital technology and automation will be routinely used by Pharmacy in Wales to accurately check dispensed medication.
6C	Strategy in Wales - Wales works in a flexible and agile approach to implementation and adoption of new technologies.
6E	Strategy in Wales - Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology.
8B	Culture of Pharmacy in Wales - Other professions are more willing to embrace digital tools.
8D	Culture of Pharmacy in Wales - Pharmacists are too risk averse to embrace new technology.
8E	Culture of Pharmacy in Wales - Pharmacy has poor vision for the business change that technology enables.
8F	Culture of Pharmacy in Wales - Community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies.
9E	Workforce and skills - The aging demographic of some staff groups in Pharmacy is hampering the implementation of technological developments.

Popularity of Likert Response Selected

Figure 72 overleaf illustrates the proportion of each type of response chosen by participants for questions 5 to 9 in the individual rounds of the study as well as the combined responses. The five questions assessed the panel's views on the pharmacy workforce, strategy, digital infrastructure and the profession in relation to technology and AI. As evident from the graph, the most commonly selected response among the experts was 'somewhat agree,' accounting for 45.82% of their overall replies. Conversely, the least popular response was 'strongly disagree,' with only 2.46% of the responses.

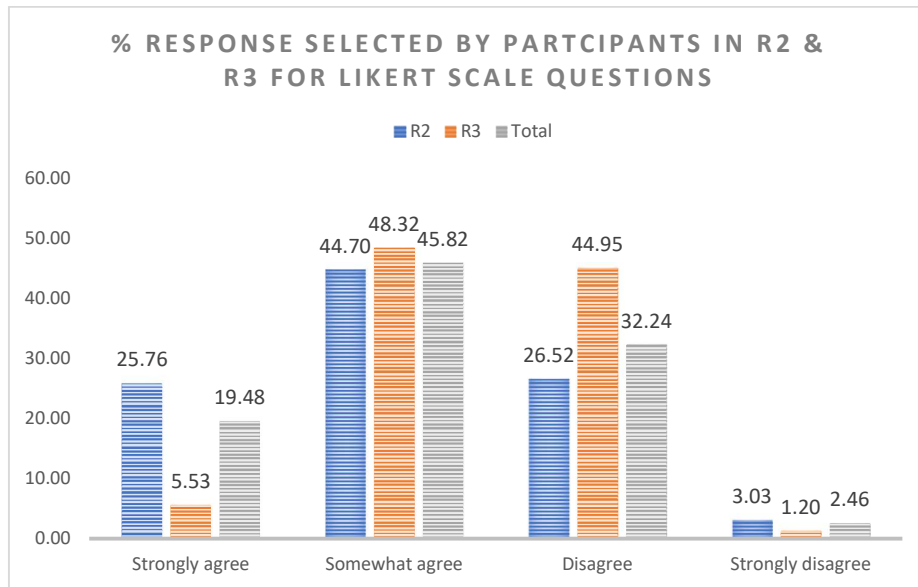


Figure 72. Percentage of Likert scale responses selected by panel Q5 to Q9.

4.5.2 Ranking Questions- Round Three

The ranking questions used in round two determine the panel's development priorities for pharmacy in the future, were repeated in round three.

Priority for utilising digital technology and automation in pharmacy by the year 2050.

For this question, the participants were asked to rank what digital technology and automation developments would be most beneficial for pharmacy by 2050. Figure 73 shows 'A fully integrated digital health record accessed across all NHS organisations' remained as the highest priority for the panel.

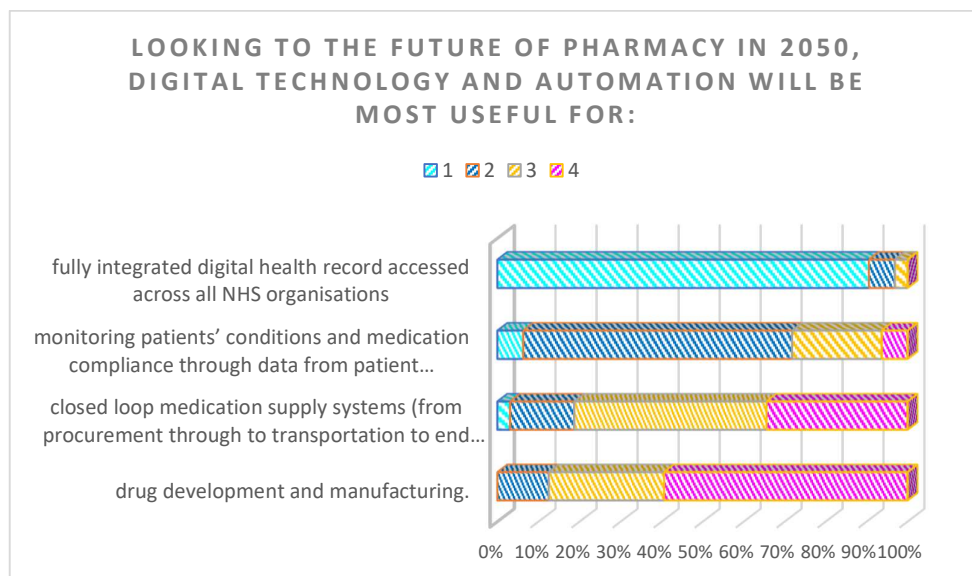


Figure 73. Stacked bar graph of % participant ranking for Round Three Question 3, where Rank 1= highest priority.

Priority for utilising artificial intelligence and machine learning in pharmacy by the year 2050

This question required participants to rank what they thought would be the most beneficial developments in AI and ML for pharmacy by 2050. The bar graphs in Figure 74 show the percentage ranking chosen by the participants for each statement (rank 1-6, where rank 1 is the highest priority). In round three 'full genomic profiling to guide optimum prescribing and generate individualised treatment plans' was the highest ranked priority by the panel.

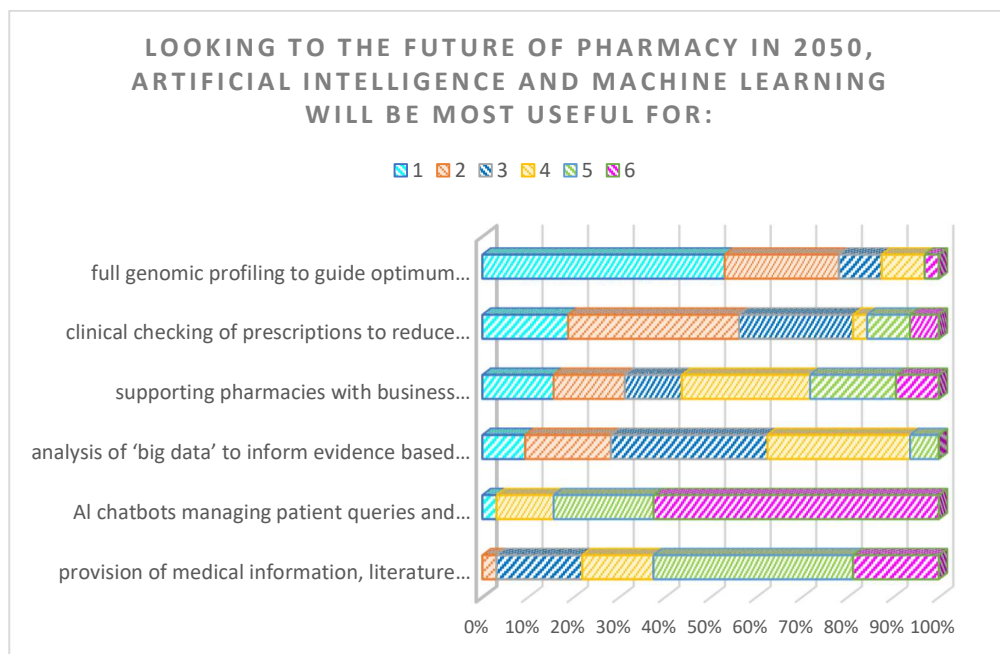


Figure 74. Stacked bar graph of % participant ranking for Round Three Question 4, where Rank 1= highest priority.

Determining the Priorities for Digital Technology and Automation in Pharmacy by 2050.

Descriptive statistics were used to calculate the mean or average ranking for each option. A lower mean ranking indicated that the statement was more favourable or a priority overall for the panel.

In both rounds, participants thought a 'fully integrated digital health record accessed across all NHS organisations' would be the most beneficial use for digital technology and automation in the future. In round two, 21 (64%) participants ranked this as the top priority. This increased to 29 (91%) in round three. The mean ranking position of all the statements in this question remained the same for both rounds. Results are shown in Table 24 overleaf.

Table 24. Mean participant ranking for future digital technology and automation priorities.

Looking to the future of Pharmacy in 2050, digital technology and automation will be most useful for:		Mean ranking	
		R2	R3
3B	fully integrated digital health record accessed across all NHS organisations.	1.58 (1 st)	1.13 (1 st)
3C	monitoring patients' conditions and medication compliance through data from patient wearables and devices.	2.15 (2 nd)	2.28 (2 nd)
3D	closed loop medication supply systems (from procurement through to transportation to end user).	2.97 (3 rd)	3.13 (3 rd)
3A	drug development and manufacturing.	3.30 (4 th)	3.47 (4 th)

Determining the Priorities for AI and ML in Pharmacy by 2050.

The mean ranking was calculated for each statement in both rounds. The closer the mean ranking was to 1, the higher the priority of the future application of AI and ML stated. Across both rounds 'full genomic profiling to guide optimum prescribing and generate individualised treatment plans' was the highest ranked priority. In round two 14 participants (42%) ranked it first and this increased to 17 (53%) in the third round. The use of 'AI chatbots managing patient queries and providing advice' was determined to be the least valuable application of AI and ML in future pharmacy. For round two, 14 participants (42%) ranked it last, which increased to 20 (63%) in round three. The results for both rounds are shown in Table 25.

Table 25. Mean participant ranking for future AI and ML priorities.

Looking to the future of Pharmacy in 2050, artificial intelligence and machine learning will be most useful for:		Mean ranking	
		R2	R3
4B	full genomic profiling to guide optimum prescribing and generate individualised treatment plans.	2.21 (1 st)	1.88 (1 st)
4D	analysis of 'big data' to inform evidence based prescribing and horizon scanning.	3.09 (2 nd)	3.06 (3 rd)
4F	clinical checking of prescriptions to reduce avoidable adverse drug reactions and drug interactions	3.30 (3 rd)	2.66 (2 nd)
4C	provision of medical information, literature searching and interpretation of clinical studies	3.85 (4 th)	4.56 (5 th)
4A	supporting pharmacies with business intelligence and workforce demand management	3.88 (5 th)	3.47 (4 th)
4E	AI chatbots managing patient queries and providing advice.	4.67 (6 th)	5.38 (6 th)

4.5.3 Summary

Agreement of opinion among experts evolved throughout the Delphi process, with a further two Likert statements reaching consensus in the third round of the study. However, there were eight statements, mainly relating to 'Culture of pharmacy in Wales, where the experts failed to agree. The two ranking questions produced consistent high priorities for future developments in pharmacy across the two rounds

4.6 CHAPTER SUMMARY

This chapter has provided an overview of the results from the Delphi study's three rounds of expert panel surveys undertaken via the online platform Qualtrics. The first questionnaire was sent to 54 eligible pharmacists and received 38 responses for the first round. Of these 38, all work in Wales and most (84%) have been practising as a pharmacist for over twenty years. The hospital pharmacy sector is the most represented in terms of area of expertise (50%), the majority of participants are aged between 45 and 55 years old and there is an almost equal gender distribution. There was some attrition during the study, with 33 completing round two and 32 round three. Approaching potential panellists prospectively was seen to improve recruitment and completion rates throughout the study.

The data from the 41 round one qualitative questions was analysed and used to generate the quantitative questions for the subsequent rounds. Of the 39 Likert statements considered in

the second round, 26 reached consensus agreement. 13 were then presented to the panel again in round three and a further 5 gained consensus. In total, 31 out of the initial 39 Likert questions attained a consensus of over 70% among the panel members after both quantitative Delphi rounds.

Over the three rounds, the expert panel achieved a high level of consensus on the perceived challenges in financing and implementing digital advancements, as well as the crucial role of pharmacists in overseeing AI systems and maintaining clinical decision-making responsibilities in the future. The experts concurred that patients would favour human pharmacists for their care and that AI technology could not substitute for essential pharmacist-patient interactions. They expressed optimism regarding the profession's digital aspirations and supportive national strategy and considered Wales an ideal location for testing and expanding technological innovations. Additionally, they anticipated that by 2030, digital technology and automation would be utilised in medicine procurement and the sharing of patient medication data.

The next chapter provides a critical discussion of these results, interpreting them in the context of existing literature in the field. It will examine how the findings address the research objectives, explore their implications for pharmacy practice and policy and identify areas for further research.

Chapter 5. Discussion

5.1 INTRODUCTION

In this chapter, the findings from the Delphi study are discussed in the context of the research objectives and body of knowledge explored in the literature review. The chapter examines the key findings from the study in terms of the opportunities for pharmacy through the integration of technology and AI into practice and also some of the challenges the profession may face in the future. The strengths and limitations of the research study are considered, and suggestions are made for further research avenues to build on these findings.

The Delphi study aims to critically explore the perspectives of pharmacy leaders in Wales on the impact of emerging technologies on contemporary pharmacy practice. To this end, the research objectives, which will be achieved through consensus, are outlined as follows:

- To assess pharmacists' opinions regarding the potential for digital technology, automation and AI to either replace or assist with pharmacy functions and duties by the year 2030.
- To ascertain pharmacists' priorities concerning future technological advancements in their practice in Wales.
- To critically explore pharmacists' views on the potential impact of digital technology, automation and AI on the pharmacy workforce in Wales.
- To critically examine the factors that pharmacists believe may facilitate or impede the implementation of digital technology, automation and AI in pharmacy practice in Wales.

The results from the previous chapter are examined against each of these objectives and compared with findings from other studies across healthcare.

5.2 PHARMACIST OPINIONS REGARDING THE POTENTIAL FOR DIGITAL TECHNOLOGY, AUTOMATION AND AI TO REPLACE OR ASSIST WITH PHARMACY FUNCTIONS AND DUTIES BY 2030

The initial inquiry asked the panel of expert pharmacists for their predictions on the anticipated prevalence of digital technology, automation and AI in pharmacy by the year

2030. Likert scale questions were utilised to assess whether the participants believed that developments suggested in the first-round responses were likely to be implemented in pharmacy by the year 2030.

As detailed in the methodology chapter, rather than ask the panellists to make a vague prediction of what developments might occur in the short or near term or over the next decade, the year 2030 was included in the study to make a connection between the survey questions and the Welsh Pharmaceutical Committee's PDaHW vision (2019) which has set a number of objectives for the profession to be delivered by 2030. This link was made to increase interest and improve response rates from potential participants.

One of the four themes in the PDaHW vision is "Harnessing Technology and Innovation". There are a number of underpinning aims stated within this theme, including the digitalisation of the entire medicines prescribing, supply and administration process and ensuring technological advancements are used to help individuals achieve the best possible health and medication outcomes. The two specific 2030 goals included in this theme are:

'Patients central electronic medical records are accessed and updated by practitioners involved in their care, including the pharmacy team.'

'Supply of medicines is automated and supported by Artificial Intelligence.'

5.2.1 Shared Medication Data

In relation to the first PDaHW target, namely access to the complete medical record by 2030, the panel thought only a patient's medication data would be shared and transferred across healthcare providers in Wales by that date, not the full health record. However, the participants thought this prediction was highly significant and they ranked it the second most important statement of all the Likert questions.

This finding is consistent with Tolley *et al.*'s (2023) study which highlights the importance of a shared consolidated medication record. Their participants emphasise that access to an accurate and up-to-date medication record is essential to realise the future ambitions of

digital medicines optimisation services. The authors report access to a shared medication record would ensure that individuals derive maximum benefit from their medications while minimising potential harm. The earlier research by Mercer *et al.* (2018) also demonstrates the advantages of access to electronic medication records particularly for pharmacy teams, from accurate reconciliation of medicines when patients move between care settings and to improvements in medicines safety and patient outcomes.

In this study the significance the expert pharmacists placed on the shared medication record may have been influenced by the timing of the research project. At the time of surveying the expert panel, the national digital organisation for Wales, DHCW, had been promoting the advances they were making in developing the first-ever Shared Medicines Record for patients in Wales, as part of their Digital Medicines Transformation Portfolio for NHS Wales. Their aim was to have an accessible Medicines Record for all patients, with access granted to all health professionals in order to reduce the duplication of medication history-taking and minimise medication errors during transfers of care (Digital Health and Care Wales, 2024b). However, the timeline for the implementation of the shared medication record had drifted somewhat.

5.2.2 Automation of Medication Supply

The second PDaHW 2030 goal of the Welsh Pharmaceutical Committee within the theme of Harnessing Technology and Innovation, relates to automating the supply of medicines as well employing artificial intelligence to support. In this study, the panel forecast that technology and automaton would be utilised in several steps of the medication supply chain by the year 2030. The panellists predicted that the dispensing of prescriptions would be routinely automated across all pharmacy sectors by 2030, along with the supporting functions of medicines procurement and invoicing.

Through a Welsh Government funding initiative to redesign pharmacy services and embrace cutting-edge technology, the majority of pharmacies in Welsh NHS hospitals have implemented automated dispensing systems, although these are less commonly found in community pharmacies (James *et al.*, 2011). The Welsh Government allocated funding over the past few years to provide community pharmacies with the means to install automated

prescription collection systems, with the aim of improving access to medications for patients 24 hours a day and enhancing the overall efficiency of pharmacies (Welsh Government, 2021b). While the uptake of this funding has not been universal, the expert panel predicts that the implementation of automated medicines supply cabinets across pharmacy settings will become more widespread by 2030. A notable finding from the data indicates that community pharmacists are more inclined than other panel members to anticipate this development, with all expressing the belief that it will materialise by 2030. Although the Portuguese study of community pharmacists found automation did not significantly improve job satisfaction or increase the time available for patient-facing care (Cavaco and Krookas, 2013) the optimism of Welsh community pharmacists regarding this development may be attributed to their direct experience of current capacity challenges in the sector and the potential benefits they envisage for their operations. Encouragingly, their enthusiasm may foster innovation and encourage wider adoption of automated dispensing solutions in the forthcoming years.

The panel did not reach a consensus on whether the automation of accuracy checking dispensed prescriptions would be a reality by 2030. Although this was a high frequency code used during the first Delphi round, there is no clear evidence in the published literature to support either view. While the majority of community-based pharmacists believed it was likely to occur, the pharmacists from other sectors had differing opinions. In this study, uncertainty persists among pharmacy professionals regarding this development. Further research with software suppliers could investigate whether the current systems possess the technological capability to implement this practice. Additionally, the legal and regulatory implications of this development require further exploration.

5.2.3 Artificial Intelligence in Pharmacy Training and Education

Although the WPC's goal in PDaHW was rather vague to ensure medicines supply is supported by AI by 2030, there were a number of predictions of the use of AI in pharmacy made by the experts in this study. According to the panel, the most prominent use of AI in pharmacy by 2030 will be the application of AI and ML in training and education, particularly in aiding with the development, delivery and assessment of courses. It is noteworthy that the pharmacists

who have expertise in education were more likely to concur with this prediction, with 100% of them agreeing or strongly agreeing with the statement.

There are limited examples of the successful incorporation of AI into pharmacy courses, with various obstacles hindering its adoption. As discussed in the literature review, Smetana *et al.* (2024) found the majority of the pharmacists they surveyed recognise the potential benefit of AI in education for data analysis and research literature summation. However, the participants indicate a need for additional training in this area and perceive a number of barriers to integration, including lack of familiarity with AI tools, worries about the accuracy of AI-generated information and privacy concerns.

Other authors highlight the need for pharmacy education curricula to adapt to the evolving professional landscape influenced by digital technology and AI. Amalanathan (2024) recognises its significant potential to enhance student engagement in pharmacy education but stresses it is crucial to carefully assess the quality and depth of learning experiences these technologies facilitate. Cain, Malcom and Aungst (2023) recommend pharmacy students' skills should be developed to improve their ability to critically evaluate AI-enhanced work. Allowais *et al.* (2024) advocate for enhancing digital literacy among pharmacy undergraduates, recommending universities provide a theoretical understanding of health informatics and offer students opportunities to use diverse digital technologies with interprofessional collaboration.

In this study, the panel anticipates an increasing integration of AI in Welsh pharmacy education within a relatively short timeframe. Consequently, it is recommended that the pharmacy sector as a whole initiate discussion on how AI can enhance future pharmacy practice. This study provides the impetus to pharmacy educators and researchers, who are pivotal in this development, to adapt their teaching methods and ensure a greater incorporation of AI technology in the curriculum at both undergraduate and post-graduate levels. This will better prepare pharmacy students and professionals to address the evolving demands of healthcare in the future.

5.2.4 Artificial Intelligence Enabled Chatbots

In addition to the potential role for AI-supported tools in pharmacy education, the panel forecasts the routine utilisation of AI chatbots for the providing medication advice and patient counselling by 2030. Other researchers have suggested potential advantages of employing AI chatbots in healthcare settings, such as enhancing medication adherence, facilitating health behaviour change, and delivering evidence-based information on disease management and treatment options (Altamimi *et al.*, 2023; Bekbolatova *et al.*, 2024; Görtz *et al.*, 2023). However, as the literature review indicates, there is a paucity of studies within the pharmacy domain, particularly in the UK context. Further research is necessary to establish the accuracy of AI-enabled chatbots in this field and to provide additional evidence of improved patient outcomes, thereby increasing the profession's confidence and future utilisation.

5.2.5 Artificial Intelligence for Medicines Information

The panel predicts the routine use of AI and ML in the provision of medicines information to other health professionals by 2030. Although the literature review revealed minimal reference to this application, with only two participants acknowledging it in Yousif *et al.*'s (2024) study of healthcare professionals in Pakistan, there are promising examples of developments in this area. Notably, AI-based tools are being developed to formulate personalised treatment plans and offer tailored medicinal advice to specialist clinicians, particularly in oncology, as documented by Netherton *et al.* (2021) and Liefwaard *et al.* (2021). However, these advancements appear to be confined to specific or very specialised disease areas, rather than the broader medicinal information services and advice typically utilised by pharmacists.

A recent editorial article in the European Journal of Hospital Pharmacy cautioned against the potential obsolescence of medicines information pharmacists if “en vogue artificial intelligence tools” were to replace them (Stemer and Williams, 2024, p.1). Nonetheless, the article advocated for a coexistence between technology and human expertise, wherein AI tools can provide valuable information to support clinical queries yet still necessitate the pharmacist's expertise to interpret the data in relation to the individual patient's condition and circumstances. This aligns with other findings from this study, suggesting that

pharmacists will remain essential for providing expert oversight of AI-enabled tools and will be supported, rather than replaced, by technology in clinical decision-making.

5.2.6 Artificial Intelligence to Assist Clinical Validation of Prescriptions

According to the panel's predictions, AI is expected to play a pivotal role in clinical validation of prescriptions by 2030. This process typically encompasses the verification of dosages and therapeutic drug monitoring, the identification of drug-related issues and the prevention of medication errors (Naserallah *et al.*, 2020). Although several panellists proposed this application of AI in the initial round of the study, they did not provide a comprehensive definition of their proposal and there is limited published literature supporting this prediction. Some researchers have indicated the potential of AI technology to assist pharmacists in hospital clinical pharmacy settings, albeit without specifying a timeline for its implementation. It is anticipated that AI will, in the future, support pharmacists in clinical tasks by analysing large patient datasets to prevent medication errors, aid in the selection of appropriate therapies and dosages, and mitigate the risk of medication interactions and adverse events in high-risk patients (Raza *et al.*, 2022; Ranchon *et al.*, 2023; Chalasani *et al.*, 2023).

A significant observation from this study was that younger pharmacists, aged less than 45 years, displayed greater cynicism towards the advancements that will be made in technological AI in the short term. Approximately 40% of the younger panellists believed that there would be no change in the field by 2030, in contrast to only 7% of older participants. This finding aligns with the weak correlation between the age of healthcare professionals and their level of scepticism towards AI advancements in primary care reported in Blease *et al.*'s 2018 study of GPs. This unexpected result reinforces the earlier recommendation of this study, emphasising the importance of incorporating AI-based education into the undergraduate curricula for pharmacy students and enhancing the digital skills of the workforce to encourage the usage of AI technology by future pharmacy professionals.

Upon reviewing the qualitative dataset from the initial round, it was observed that a few participants expressed extreme predictions about the impact of digital technology and AI on

pharmacy in the future. While some believed that there would be no change, one participant (#21) asserted that *“everything we do could potentially be replaced”*. However, in the subsequent rounds, the majority of panel members believed that significant progress would be made in the utilisation of AI and ML by the year 2030. Four individuals held the opinion that no change would occur, but notably, none of these responses were provided by pharmacists practicing in community pharmacy settings. It appears that the community sector is optimistic about the transformative potential of AI in the field of pharmacy. This view is corroborated by the findings of the study by Syed and Al-Rawi (2023) investigating the attitudes of community pharmacists in Saudi Arabia towards AI. The results of their research indicated that community pharmacists held favourable opinions of AI, believing that it would assist healthcare professionals in their work and enable them to perform more effectively.

5.2.7 Summary

According to the panel's projections, by the year 2030 patients in Wales will have access to a shared medication record and the dispensing of medicines will be entirely automated. Moreover, the panel anticipate that AI will be widely utilised in educational and training contexts, support the clinical validation of prescriptions and deliver medication information to other healthcare professionals and advice to patients by that date. These forecasts regarding the application of technology and AI in pharmacy significantly exceed the 2030 objectives set out in PDaHW (Welsh Pharmaceutical Committee, 2019). However, it should be acknowledged that this field is continuously evolving, and the aforementioned publication was released in 2019 when the use of digital technology in pharmacy was not widespread. The COVID-19 pandemic, which occurred after the document's release, significantly accelerated the integration of technology in healthcare.

5.3 PHARMACIST PRIORITIES CONCERNING FUTURE TECHNOLOGICAL ADVANCEMENTS IN THEIR PRACTICE IN WALES

Ranking questions were utilised to ascertain the panel's future priorities. These questions were developed from a list of statements through the analysis of the first-round qualitative data. The stability of the group's responses concerning these priorities was also assessed, as the questions were presented in their entirety for rounds two and three of the study. In the

third round, the cumulative percentage of first or second high-priority choices from the previous round was included for each statement.

5.3.1 Digital Health Record

The most significant statement for the panel concerning advancements in digital technology and automation over the next 25 years in pharmacy was the establishment of a fully integrated digital health record accessible across all NHS organisations. The panel rated this development a high priority in both the second and third rounds of the Delphi study aligning with other research that underscores the importance of a comprehensive digital patient record (Kosari *et al.*, 2020; Tolley *et al.*, 2023). Electronic Health Records (EHRs) facilitate authorised real-time access to clinical information for healthcare professionals across various healthcare sectors and providers. EHRs have been demonstrated to reduce work duplication, enhance audit and research capacity, free staff from administrative tasks to engage in more patient-facing roles and ultimately improve patient safety and quality of care (Seymour, Frantsovog and Graeber, 2012; Alex *et al.*, 2016; Enahoro *et al.*, 2024). The studies examining pharmacists' perspectives on EHRs, as included in the literature review, report perceived benefits such as improved continuity of care, a reduction in medication errors and the ability to make more informed interprofessional medication-related decisions (Mercer *et al.*, 2018; Kosari *et al.*, 2020, Tolley *et al.*, 2023). However, the research also identifies potential barriers to EHR implementation, including pharmacists' concerns regarding patient confidentiality, system interoperability, data accuracy, and a reluctance among healthcare professionals to share information. This study highlights the critical role of the digital patient record in pharmacy practice in Wales, and consequently, recommendations should be directed to DHCW to ensure future access to the health record for pharmacists.

5.3.2 Patient Wearables

The panel's consistent high rating in both Delphi quantitative rounds indicated the significance they attribute to the use of patient wearables and devices by 2050 for monitoring patients' conditions and providing medication compliance data. Research has published on the current role of wearable devices in chronic disease management by providing continuous monitoring of health parameters, such as heart rate, respiratory rate and blood pressure (Guo

et al., 2021; Chalasani *et al.*, 2023). In particular, with regard to uses in pharmacy, these devices have been shown to support patients in adhering to their medication regimes (Aungst, Franzese, and Kimet, 2021). Importantly, a positive correlation has been demonstrated between individuals who engage with health activity tracking and their likelihood of adhering to their medication regimens, as well as experiencing better health outcomes (Quisel *et al.*, 2019). The future benefits of wearable technology and their ability to connect and integrate with other health data and medical records through “cyber-physical systems” will enhance the accuracy and timeliness of patient data (Lin *et al.*, 2024, p.141). Their integration with advanced data analytics and AI algorithms could elevate wearables to health predictive tools in the future (Adeghe, Okolo and Ojeyinka, 2024). This study confirms the importance and future potential of medical wearable technology in the fields of healthcare and specifically pharmacy.

5.3.3 Big Data Analysis and Prescription Clinical Checking

The study indicates that pharmacists attach great importance to the potential of AI and ML to analyse big data to inform evidence-based prescribing and to perform clinical checks on prescriptions to prevent avoidable adverse drug reactions and drug interactions by the year 2050. This aligns with other research emphasising the use of digital health records for data analysis and AI algorithm training. Topol (2019) discusses using electronic health records to train algorithms for predicting clinical parameters like Alzheimer's disease and sepsis. AI and ML are expected to transform pharmacy practice by rapidly analysing vast datasets from patient records, medication supplies and laboratory test results (Chalasani *et al.*, 2023; Ranchon *et al.*, 2023). These tools will scrutinise free-text information in patient records, enabling clinical pharmacists to identify inappropriate medication use, conduct real-time safety and efficacy evaluations, predict adverse effects, provide tailored medication regimes and improve therapeutic outcomes (Liefwaard *et al.*, 2021; Chalasani *et al.*, 2023). However, the implementation of the aforementioned digitalised health record is essential for the realisation of these advancements in AI and ML.

5.3.4 Genomic Profiling

The panel endorsed the importance of advancements in AI and ML in order to conduct full genomic profiling to support optimum prescribing and generate individualised treatment plans by 2050. This is in line with academic discourse which discusses the potential benefits of integrating pharmacogenomics, AI and healthcare to enhance precision medicine and improve therapeutic response prediction and disease prognosis (Abdelhalim *et al.*, 2022; Atkinson, 2022). Balogun *et al.* (2024) also emphasise the opportunity for clinical pharmacists to improve personalised medication management by utilising AI and ML tools to predict drug responses based on complex genomic data.

The expert panel's views are further supported by PDaHW, which emphasises the unique scientific and clinical expertise of pharmacists, positioning them as ideal leaders in pharmacogenomics. The vision anticipates that pharmacists will work to ensure the successful implementation of the goals for the safe introduction and positive patient outcomes from precision and personalised therapies (Welsh Pharmaceutical Committee, 2019).

5.3.5 Low Priorities for the Panel

The relatively low priority accorded to digital technology, automation and AI in drug development seems to be at odds with the existing body of literature (Slee, Farrar and Hughes, 2002; Hariry, Barenji and Paradkar, 2021; Milenkovich, 2023). However, this may be attributable to the make-up of the expert panel and the absence of pharmacist representation from the pharmaceutical industry. The expert panel's composition and its limitations are discussed later in this chapter.

It is worth noting that the use of AI chatbots for managing patient medication queries and providing advice was not deemed a high priority by the panel for the year 2050, despite their earlier prediction that routine use of AI chatbots would likely occur by the year 2030. This may be due to the fact that although the panel anticipated their implementation by that date, the significance of this development to them was relatively low.

5.3.6 Summary

The results of the panel's priorities for 2050 highlight the significance to pharmacy of a comprehensive digital health record across all NHS organisations. This development would facilitate real-time access to clinical information, reduce duplication of effort, increase audit and research capacity and ultimately enhance patient safety and the quality of care. The panel also agreed that in the next 25 years, advancements in AI and ML would be essential for pharmacy to analyse vast amounts of data, perform clinical checks on prescriptions and enable full genomic profiling to optimise prescribing and create individualised treatment plans for patients.

5.4 PHARMACIST VIEWS ON THE POTENTIAL IMPACT OF DIGITAL TECHNOLOGY, AUTOMATION AND AI ON THE PHARMACY WORKFORCE IN WALES.

Based on the analysis of round one data, several subthemes were identified within the broader theme of the workforce. The Likert-scale statements used to assess the panel's opinions on the influence of technology on the pharmacy workforce were formulated using their own words, ensuring that the selected phrases accurately represented the panel's perspectives on specific issues. It was observed that the panel reached a consensus in several areas.

5.4.1 Pharmacist Oversight

One of the most highly rated statements in this section and the most significant in the entire survey for the panel, was the belief that pharmacists will always be required to provide professional oversight of AI programmes and systems. This view is supported by Aungst, Franzese, and Kimet (2021) who state that pharmacists, as a profession, possess a unique set of skills that encompasses clinical knowledge with training in various analytical techniques, making them ideally suited to lead the implementation of AI-enabled clinical platforms and their integration into digital health systems.

However, the views of the pharmacy experts in this study contradict those of community pharmacists in Jordan (Jarab *et al.*, 2023) detailed in the literature review, who believe that the necessity for human supervision of AI was a hindrance to its implementation. This

disparity could be attributed to the restrictions of this present study, which has only enlisted 'expert' pharmacists who might be working at a higher or managerial level in comparison to the community pharmacists in Jordan and have more knowledge of the capacities of AI, or it could be ascribed to the variances in healthcare systems and pharmacy educational programmes between the UK and Jordan.

5.4.2 Aid to Decision Making

The panel overwhelmingly agreed that AI would serve as an aid to pharmacists in their clinical decision-making process, rather than replace them entirely. This viewpoint aligns with the literature that highlights the potential benefits of AI-enabled tools in future clinical decision-making in healthcare (Lui *et al.*, 2023; Jaber *et al.*, 2024; Syed and Al-Rawi, 2024). The results of this study are consistent with the research conducted on pharmacists, which have generally expressed an optimistic outlook on the supportive nature of AI rather than a fear of replacement (Alanzi, 2023; Jaber *et al.*, 2024; Jairoun *et al.*, 2024). Studies of other healthcare professionals suggest that AI is unlikely to replace them but rather assume specific healthcare tasks, such as completing documentation, improving diagnostic accuracy and enhancing the efficiency of certain administrative processes (Blease *et al.*, 2018; Buck *et al.*, 2022).

5.4.3 Human Touch

According to the panel, the act of pharmacy staff engaging with patients to determine if they are taking their medications correctly is a critical aspect of care that cannot be replicated by AI. This conclusion aligns with the findings of Blease *et al.* (2019), who, in their survey of GPs, emphasise the importance of the doctor-patient interaction in the efficient gathering of medical information. Furthermore, the panel in this current study endorsed the notion that patients will consistently opt for human gatekeepers in the provision of their pharmaceutical care.

Studies of GPs have shown that they share the belief that technology cannot substitute for human competencies in delivering empathic care, nor can it replace the importance of face-to-face communication with patients, and patients actively desire it (Blease *et al.*, 2018; Buck *et al.*, 2022). The pharmacists' view in this study, that AI cannot replicate the personal touch

of face-to-face contact ensuring that patients and healthcare professionals to derive the greatest benefits from their interactions, aligns with this wider literature. Advances in technology and AI should be promoted by healthcare organisations as a way to assist the work of healthcare professionals and also release them from non-patient facing tasks in order provide capacity for more rewarding interactions with patients in most need of human care (Esmaeilzadeh, 2024).

5.4.4 Digital Skills and Training

The experts agreed that there is a lack of digital skills and expertise in pharmacy, aligning with many of the findings from the pharmacy research discussed in the literature review (Afolabi and Oyeibisi, 2007b; Alanzi, 2023; Yousif *et al.*, 2024). Jarab *et al.* (2023) found the majority of the community pharmacists reported a lack of information and education on AI but were eager to receive ongoing and training, citing career advancement as a motivation for interest in the subject.

Student and professionals across other healthcare disciplines have shown enthusiasm for the inclusion of AI-related content in their training, as evidenced by research from Pinto do Santos *et al.* (2019) and Bisdas *et al.* (2021). Notably, despite significant progress in AI integration within radiology, Hashmi *et al.* (2023) indicate that UK radiology trainees have limited exposure to AI-related teaching yet express a keen interest in further education on fundamental AI concepts, implementation strategies and critical evaluation of AI software.

In the field of pharmacy education, Syed and Al-Rawi (2023) note that a substantial proportion of pharmacy students surveyed in Saudi Arabia have not received formal AI education, despite expressing a desire for increased AI training in their degree programmes. Likewise, Busch *et al.*'s (2023) multinational research on pharmacy undergraduates reveals limited general AI knowledge and a sense of unpreparedness for future professional engagement with AI technologies.

The necessity for Schools of Pharmacy to acknowledge the importance of enhancing pharmacy students' proficiency in digital technology and AI should be recognised (Jermutus

et al., 2022). Cain, Malcom and Aungst (2023) highlight the significance of developing an understanding of emerging technology in pharmacy undergraduates, equipping them with the skills and judgement to assess the quality of AI-enabled tools and better prepare them for their future roles. Allowais *et al.* (2024) also provides practical recommendations to improve digital literacy education in undergraduate pharmacy programmes. They recommend providing a theoretical understanding of health informatics and AI and offering students opportunities to use diverse digital technologies with interprofessional collaboration.

The need for postgraduate training opportunities to improve the digital skills of qualified professionals after their formal education has also been highlighted. The influential Topol Review, commissioned in 2019 to prepare the NHS workforce for a digital future, recommends that healthcare organisations should facilitate the development of the “skills, attitudes, and behaviours necessary for individuals to be digitally competent and confident” (Topol, 2019, p. 78).

The importance of supporting the current pharmacy workforce in Wales to prepare for technological advancements has been acknowledged in the recent Health Education and Improvement Wales Strategic Pharmacy Workforce Plan (2023). The plan includes the ambition to build a ‘digitally ready’ pharmacy workforce, again using the 2030 year, aligned to the PDAHW vision, as a stated target:

‘By 2030, the digital capabilities of the pharmacy workforce will be well developed and widespread to help us deliver the best possible care for people using the latest advances in technology’

HEIW will facilitate this through the provision of a self-evaluation tool that aligns with a digital capability framework. This tool will enable individuals to assess and develop the digital, technology and informatics skills and behaviours required to succeed in the digital environment. Additionally, the plan aims to expand the HEIW network of Digital Champions to include pharmacy team members. This will provide interested individuals with access to further training and opportunities to pursue formal education to become digital specialists.

5.4.5 Digital Specialists

The panel endorsed the key role that clinical informatics pharmacists can fulfil in leading digital developments. Although these roles are in their infancy in the UK, their advantages have been demonstrated elsewhere (Falconer, Monaghan and Snoswell, 2021; Bakker *et al.*, 2024).

Aligning with the panel's priority, HEIW's Strategic Pharmacy Workforce Plan aims to cultivate "digital clinical leaders within pharmacy to influence and lead digital transformation" (HEIW, 2023, p. 27). HEIW emphasised the importance of specialised roles, such as Chief Pharmaceutical Information Officers, to ensure quality and safety during the digitalisation of medicines-related systems and processes. The plan supports the enhancement of advanced digital, technological and informatics skills for pharmacy professionals through UWTSD's Digital Skills Framework (University of Wales Trinity Saint David, 2022). Nevertheless, as previously mentioned, these digital clinical leaders will need to be assured of the overall digital proficiency of their pharmacy colleagues and other healthcare personnel to effectively implement and operationalise digital transformation within the healthcare sector.

5.4.6 Role Replacement

In relation to role replacement, the study revealed that the participants did not voice any apprehensions with regard to the potential adverse effects of technology and AI on employment in pharmacy or replacement of human workers. These results align with the early US study by Crawford *et al.* (1998), detailed in the literature review, where pharmacists did not perceive automation would threaten their jobs. However, the views of technicians were not sought in this current research, so it cannot be ascertained if technicians in Wales would echo their US counterparts by expressing some negative views of technology. Community pharmacists in Jordan (Jarab *et al.*'s, 2023) did not express any fear of being replaced by AI in their role and similarly Syed and Al-Rawi (2023) report that pharmacy undergraduates share this positive perspective, as only a minority of respondents agree that AI could replace a physician, pharmacist or nurse in the healthcare system.

Whilst in this study the pharmacists did not express the “existential anxiety” revealed in Buck *et al.*'s (2022, p. 6) study of GPs working in Germany, the panel's predominantly favourable opinions regarding AI's potential to enhance their roles might be challenged if one subscribes to the concept of “self-preserving optimism bias”, proposed by Blease *et al.* (2023, p. 5). As described in the literature review, the authors define this phenomenon as the tendency for individuals to underestimate the consequences of technological advancements on their specific area of expertise or profession. Although their study has been conducted on medical students, the findings may have relevance to pharmacy professionals. Additionally, the importance of increased AI literacy through education to understand the principles of AI, its capabilities and its limitations is essential for the workforce of the future, as emphasised by Jermutus *et al.* (2022).

Despite the participants' belief that job replacement was not a cause for concern, they did agree that a significant cultural shift was necessary in pharmacy in order to embrace technology rather than fear it. Due to these differing views and apprehensions, it is important to consider the advice of Lui *et al.* (2023) that all efforts must be made by the profession to address any fears or concerns regarding the potential displacement of healthcare workers by AI systems in order to fully realise the benefits of technological advancements.

5.4.7 Summary

Throughout this study, the majority of the panel expressed optimistic views concerning the impact of technological advancements on pharmacy. The pharmacists indicated minimal concerns about job displacement and emphasised the importance of professional oversight for AI systems. They acknowledged the benefits of technology and AI in assisting them with decision-making processes, while also recognising the invaluable role of human interactions with patients. Of the few areas of concern identified, one was the agreement that there was an insufficient level of digital skills and expertise within the profession. This important finding aligns with the literature from other healthcare disciplines and underscores the need for education providers, employers and the profession as a whole to address this critical issue.

5.5 FACTORS THAT PHARMACISTS BELIEVE MAY FACILITATE OR IMPEDE THE IMPLEMENTATION OF DIGITAL TECHNOLOGY, AUTOMATION AND AI IN PHARMACY IN WALES.

The themes for this topic were derived from the initial round of data collection, utilising the panel's own language and expressions to develop the Likert statements. This approach ensures that the subsequent survey questions accurately reflect the participants' perspectives and experiences, enhancing the validity and relevance of the research instrument.

5.5.1 Financial Constraints

One of the panel's most significant observations related to digital developments in Wales was the substantial challenge of finances, with all panel members except one (97%) agreeing that this was an obstacle to the implementation of technology. The funding constraints identified for pharmacy in Wales align with the study of Jordanian community pharmacists (Jarab *et al.*, 2023), where the majority (75%) reported that the high running costs of AI were a barrier to implementation. These views are consistent with the published literature across other healthcare disciplines, where the high costs associated with equipment, software development and training have been reported as a constraint to the implementation of technology and AI (Alsobhi *et al.*, 2022; Borges do Nascimento *et al.*, 2023; Esmaeilzadeh, 2024). The Welsh Government's commitment to support long-term investments in enhancing digital infrastructure and technology (Welsh Government, 2021a) could result in a sustainable funding model for digital innovation across pharmacy. This approach might alleviate some of the issues raised by the panel.

5.5.2 Geography of Wales

The small size of Wales was thought by the panel to serve as both a benefit and a hindrance in relation to digital development. According to most of the experts (94%), one highly rated advantage of a small country is the ability to trial innovation and scale up good practice rapidly. Another enabler recognised by the majority of the panel (73%) was Wales's potential to co-ordinate and implement wide-spread change through established networks and a limited number of organisations. The panel agreed that NHS Wales should adopt a 'Once for Wales' approach for the scoping, tendering, procurement and deployment of technology in order to ensure system standardisation and interoperability. Nevertheless, in a contradictory

finding, 75% of the participants agreed that the size of Wales made it less commercially attractive to system suppliers and unable influence any bespoke IT developments. The panel also concurred (73%) despite its size, decision-making in NHS Wales was not streamlined and there were still hurdles to overcome in respect to governance for digital projects.

The experts agreed that NHS Wales benefits from a nationally managed digital infrastructure, highlighting the advantages of a small healthcare system. This aligns with the research by Hoban *et al.* (2024), which described Wales's edge over Australia in terms of its co-ordinated and integrated digital health infrastructure, as well as its capacity to generate and share health-related information across a limited number of organisations.

The panel not only referred to the size of the country, but also to its geographical categorisation. Despite its relatively small population and geographical area, Wales features a largely rural setting in comparison to other parts of the UK (Johns *et al.*, 2023). The panel agreed (79%) that this feature necessitates the improvement of access to remote healthcare and the guarantee of the availability of medications in remote regions. As highlighted in the literature, when developing and deploying healthcare technologies within the Welsh healthcare system, it is crucial to develop tailored solutions that not only address the geographical obstacles but also cater to any additional specific needs of the rural population in Wales.

5.5.3 Digital Integration

The findings from the panel were not completely positive and several challenges and barriers were identified concerning the utilisation of digital technology and AI in pharmacy in Wales. The majority of the participants, amounting to 97%, agreed that a significant obstacle to the implementation of digital pilot projects is the inability to integrate and interface with broader systems. This is corroborated by Tolley *et al.*'s research (2023), which identifies concerns among participants about difficulties in employing digital tools for medicines management and optimisation. These concerns include a 'lack of intersystem and intra-system interoperability' and critical gaps in patient data across various settings. Other researchers support the panel's concerns regarding the fragmented nature of digital infrastructure and

the persistent presence of data silos across healthcare organisations, which pose substantial challenges to effective data sharing and integration (Kelly *et al.*, 2019; Lee and Yoon, 2021). These silos often emerge from the use of different IT systems and organisational divisions that inhibit interoperability and prevent the seamless exchange of clinical information across care settings. This fragmentation is particularly problematic in pharmacy, where real-time access to accurate and complete medication records is essential for patient safety and clinical decision-making (Mercer *et al.*, 2018). Furthermore, data silos constrain the effective deployment of AI technologies in healthcare, which require comprehensive datasets to improve the accuracy of their outputs and deliver patient benefits (Lee and Yoon, 2021; Bekbolatova *et al.*, 2024). In Wales, DHCW are attempting to address these limitations by developing the unified national digital infrastructure, including shared electronic health records and interoperable systems that span primary and secondary care.

A contrasting finding is that the experts agreed that placing dependence on DHCW for implementing technology may hinder progress and result in increased costs. This perspective seems to contradict their endorsement of a national digital architecture for NHS Wales. However, it is plausible that the negative sentiment was more directed towards DHCW as an organisation, rather than the concept of a national digital platform for NHS Wales. The negative views regarding DHCW were expressed by numerous pharmacists in their free-text responses in the initial Delphi round. Some examples are shown on page 109 in the Results chapter. These concerns may stem from past experiences or perceived limitations in DHCW's capacity to effectively manage large-scale technology projects and it will be crucial to address these issues to ensure successful digital transformation in Wales and to foster trust among healthcare professionals

The scepticism expressed by experts could be attributed to the ambiguity surrounding DHCW's role, as noted by Whitfield and Hamblin (2023). This lack of clarity may lead to misunderstandings about DHCW's capabilities and responsibilities, potentially hindering collaboration and progress. Inadequate communication and lack of transparency between DHCW and stakeholders could exacerbate these issues, further undermining confidence in the organisation's ability to deliver effective digital health solutions. The apparent

contradiction between support for a national digital architecture and concerns about DHCW's involvement presents a complex challenge and underscores the importance of addressing stakeholder concerns while maintaining momentum towards digital innovation in healthcare across Wales.

5.5.4 Trust

The majority of the participants agreed that digital projects in Wales have been implemented in the past without transparency or gaining the trust and confidence of the pharmacy profession. This assertion is supported by studies healthcare professions which highlight the significance of trust in digital technology and AI to ensure acceptance and successful adoption in practice (Asan, Bayrak and Choudhury, 2020; Rainey *et al.*, 2021; Jermutus *et al.*, 2022). According to Buck *et al.* (2022), the lack of trust in and acceptance of AI-enabled system by GPs is a major barrier to their adoption in primary care settings. The literature suggests that trust in technology and AI by health professionals can be multifaceted issue, influenced by many different factors. Within mental healthcare settings, Higgins *et al.* (2023) have found the significant barriers to AI integration in practice arose from the uncertainty of clinicians, failure to ensure end-user acceptance, issues with system transparency and a lack of clinician involvement in the AI development stage. In their 2022 study, Buck *et al.* raise concerns about GPs lacking trust in the datasets used to train AI systems. GPs expressed worries about potential biases or overly adapted outcomes due to the diverse and unique nature of their patients. However, the researchers simultaneously caution against the risks associated with blindly trusting AI systems, which could lead to an over-reliance on their suggestions.

Other researchers have found that healthcare professionals' trust in AI is positively influenced through enhanced governance and assurance of the AI systems and developing strategies to explain the theory of AI healthcare professionals in order to improve understanding the logic behind AI decisions (Horton *et al.*, 2021). Moreover, assuring health professionals of the assistive nature of the technology, which will help release capacity to improve their ability to provide patient-facing care, will improve their trust and acceptance in digital tools (Blease *et al.*, 2018; Buck *et al.*, 2022; Esmailzadeh, 2024).

5.5.5 Professional Pharmacy Leadership

In the third round of the Delphi study, the expert panel reached consensus that Wales benefits from strong pharmacy leadership, which has played a pivotal role in promoting collaboration and advancing the integration of digital technologies within the profession. This aligns with wider literature that underscores the importance of visionary, inclusive leadership in driving digital transformation across healthcare systems (Greening, 2019; Chen and Decary, 2020; Hogan-Murphy *et al.*, 2021). Strong leaders are instrumental not only in articulating a compelling digital vision, but also in fostering organisational cultures that support innovation, mitigate resistance to change and ensure the safe and effective implementation of new technologies (NHS Leadership Academy, 2013).

Digital transformation in pharmacy requires a shift from traditional leadership models towards more agile, digitally competent leadership. Pharmacy leaders must now possess a wide skillset encompassing digital literacy, change management, systems thinking and data governance (Topol, 2019). This evolution demands coordinated support from professional bodies, academic institutions and employers to embed digital competencies into leadership development pathways. The Royal Pharmaceutical Society in Wales and other national stakeholders should play a central role in promoting digital professionalism and positioning pharmacists as leaders within interdisciplinary healthcare teams. There is also the need for distributed leadership across the profession, where digital champions at all levels can act as champions and foster digital confidence, support cultural change and help embed new innovations across pharmacy practice (Greening, 2019).

5.5.6 Digital Strategy

The experts overwhelmingly commended the profession's vision for pharmacy in Wales as a crucial instrument to facilitate digital transformation. This outcome represents a positive finding for the WPC, demonstrating the efficacy of their collaborative approach to PDaHW strategy development. In future iterations, any revision of the PDaHW vision or the formulation of action plans to implement the strategy should be conducted in close partnership with the wider pharmacy profession in Wales, in order to secure their endorsement and willingness to adopt it.

5.5.7 Summary

In order to ensure that pharmacy in Wales can fully realise the benefits of emerging technologies, it is essential to acknowledge and address the barriers and facilitators to implementation that were highlighted in the finding of the panel. Funding should be directed towards digital technology and healthcare AI to encourage innovation. Moreover, the advantages of a small, interconnected healthcare system should be exploited to drive digital transformation in pharmacy. It is imperative that lessons are learnt from past initiatives and trust and confidence in automation and AI are enhanced through strong leadership, a clear strategy and promotion of a culture of transparency and active pharmacist engagement in digital design.

5.6 THEORETICAL IMPLICATIONS

The successful integration of digital technology, automation and AI into Welsh pharmacy practice required a strategic approach informed by sociotechnical systems theory, change management principles and technology acceptance models. This study emphasises the critical interdependence between technological innovation and workforce engagement. It highlights the importance of technology acceptance models, particularly the Unified Theory of Acceptance and Use of Technology (UTAUT) in understanding pharmacists' readiness to embrace new technologies and in fostering environments where digital transformation is seen as both beneficial and achievable. In order to fully harness the advantages of technology, the pharmacy profession should prioritise enhancing 'performance expectancy' and 'facilitating conditions,' ensuring that pharmacists view digital innovations as valuable additions to their professional roles and have the necessary technical support, skills and resources to adopt them (Venkatesh *et al.*, 2003). Achieving successful digital transformation in pharmacy requires more than just technological advancements; it demands significant changes in organisational culture, workforce capability and professional leadership.

5.7 STRENGTHS AND LIMITATIONS OF THE STUDY AND AREAS FOR FURTHER RESEARCH

This section aims to provide a balanced evaluation of the study by identifying the strengths and acknowledging any weaknesses of the methodologies and approaches employed in the research.

5.7.1 Key Strengths

At the time of publication, this study is considered to be the first Delphi study to investigate pharmacists' predictions regarding the role of digital technology and AI in the short term, as well as to identify the long-term technological priorities for pharmacy in Wales. This highlights the originality of the research and its contribution to future practice.

A notable strength of the study is the high response rate to the initial invitation (70%) and the low attrition rate of the expert panellists across the three rounds, with 82% of the initial 38 participants completing round three. The panel is also representative of a diverse range of areas within pharmacy practice and includes an equal distribution of males and females

Another strength of the project is the inclusion of a piloting stage for each round to evaluate the participant information, survey questions and layout. This process provided valuable advice and feedback to the researcher prior to finalising each questionnaire, thereby ensuring the content and face validity of the survey (van Teijlingen and Hundley, 2002; Novakowski and Wellar, 2008; Bowling, 2014).

The Delphi study employs a combination of qualitative and quantitative research methods to address the overall objectives of the research. Some modified Delphi studies omit the initial round to save time; however, it was determined that the primary strength of the initial qualitative survey lies in the rich data it generates from expert participants in an area with limited prior research (Hasson, Keeney, and McKenna, 2000). The comprehensive examination of this data through thematic analysis and open coding has produced a robust set of statements for the quantitative rounds and the inclusion of the experts' own words and phrases in these statements reduces any researcher-practitioner bias and enhances the study's reliability (Keeney, Hasson, and McKenna, 2011).

5.7.2 Key Limitations

The Delphi technique employed in this research study possesses several other intrinsic strengths, which are elaborated upon in the methodology chapter. Nonetheless, it is essential to acknowledge certain weaknesses associated with various aspects of the study, which are inherent in any research project, but importantly include the actions employed to mitigate the limitations.

The approach used to recruit the expert panel members for this study had its limitations. Due to time constraints and researcher capacity, varying recruitment measures were used to enlist participants, and it was not possible to individually approach all potential participants before the study. Table 7 (in the results chapter) illustrates this, as the 14 pharmacists who were approached prior to the research all successfully completed the three rounds of the Delphi study. Consequently, the decision to not approach all potential candidates prospectively may have had an impact on the response rate for the initial rounds and the commitment and engagement of the panellists throughout the process. A larger and more diverse panel of experts could have provided a wider range of opinions and enabled a broader examination of some of the more contentious subjects. However, a larger initial panel may not have necessarily led to such a high and continued response rate throughout the rounds (as demonstrated by Gargon *et al.*, 2019). Additionally, the cold email rather than a personalised approach resulted in a number of ineligible individuals being contacted, including those who were not registered pharmacists, which resulted in a negative impact on researcher time overall. A lesson for any future research is the importance of identifying successful strategies for participant recruitment at the initial planning stage of a study, to maximise response rates and study completion for iterative research methods (Gray, 2018). Nevertheless, the response rate is higher than anticipated and the panel size across all rounds exceeds the minimum level of 20 set at the beginning of the study by 55% even in the third round.

In the first section of the demographic questions, the opening question requests participants to identify their place of work and thus verify their eligibility for participating in the study. Three respondents, in addition to selecting Wales, indicated that they worked in 'England' or the 'Rest of the UK.' Upon further consideration, the location options provided for the

pharmacist participants could have been more specific, such as 'Wales', 'Wales & England' and 'All of UK.' Although these choices did not affect the outcomes and were not highlighted during the piloting stage group, it would have made the question more accurate and serves as a valuable lesson to bear in mind for any future survey designs.

In the course of the analysis, the excessive length and verbosity of some statements used in the quantitative rounds was identified. This was as a result of the efforts made to include the participants' own words and phrases from their responses to the initial round. On reflection, it could have been more effective to have adhered to Bowling's advice on statement development, by crafting some questions as two distinct statements to enhance clarity and avoid the questions being possibly multi modal or "double-barrelled" (Bowling, 2014, p. 313). Illustrations of this approach to divide and simplify the statements are outlined below:

Statement:

As a small country, Wales is able to co-ordinate and implement wide spread change through established networks and limited numbers of organisations.

Suggestion of revised statements:

As a small country, Wales is able to co-ordinate and implement wide spread change through established networks.

As a small country, Wales is able to co-ordinate and implement wide spread change through limited numbers of organisations.

Statement:

In NHS Wales decision-making is streamlined and there are less hurdles in respect to governance for digital projects.

Suggestion of revised statements:

In NHS Wales decision-making is streamlined.

In NHS Wales decision-making there are less hurdles in respect to governance for digital projects.

Other studies investigating the influence of artificial AI in the healthcare sector assess participants' familiarity with the fundamental principles of AI (Rainey *et al.*, 2021; Buck *et al.*, 2022; Li *et al.*, 2022; Syed and Al-Rawi, 2023). However, such an evaluation was not conducted in this study, as it would have required additional time and resources and could

have offended the experts and reduced their engagement with the study. For future research of the wider pharmacist population, it would be pertinent to incorporate questions that assess AI knowledge of the participants into the questionnaire.

Some research papers discussing the Delphi method have discussed retesting the responses to the full-length questionnaire for all the quantitative rounds (Hasson, Keeney and McKenna, 2000; Grisham, 2008). This would have enabled the reliability and stability of responses to be measured for every statement in the survey and could have reduced any bias from the attrition of certain panel members with minority views (Gargon *et al.*, 2019). Reconsidering all of the statements a second time, with the benefit of feedback on the previous scoring, would allow every statement to gain the highest importance rating and level of consensus (Keeney, Hasson and McKenna, 2011). Nevertheless, to maintain participant engagement, reduce attrition and sustain a high response rate for the third round, it was decided to limit the final survey to the 13 Likert scale questions that did not achieve expert consensus, along with the two priority ranking questions. The benefits of a shorter questionnaire in the final round were apparent from a comment made by one of the pilot volunteers, who provided feedback expressing satisfaction with how swiftly they were able to complete the survey. Following on from this comment it is important to note another potential criticism of the study was the extensive range of topics covered in the quantitative rounds, which sought the expert opinions. A more concise questionnaire, concentrating on a smaller number of topics, may have potentially increased the response rates, especially if panellists experienced question fatigue by the end of round two.

As indicated in the previous chapter's findings, the experts failed to achieve consensus on eight of the statements despite the panel's reconsideration, which could be considered an incomplete Delphi study. As the requirement to stop at three Delphi round was arbitrary and not based on any standardised guidance, additional rounds could have been conducted to provide opportunity for the participants to reach agreement. However, this approach was deemed unethical as the participants had been informed at the beginning that the study would comprise three rounds in total and subjecting them to further questionnaires may have led to reduced engagement (Keeney, Hasson and McKenna, 2011). Further research could

be conducted into the statements that did not reach consensus, especially those regarding the strategy and culture of pharmacy in Wales. This could be achieved through more detailed qualitative interviews or focus groups to provide a deeper understanding of the priorities and concerns of pharmacists in this emerging field.

As a research methodology, the Delphi technique has other shortcomings which are discussed in more detail in the methodology chapter. However, in particular relation to this research project, the potential for bias in the results through the expert panel composition and the interpretation of the initial qualitative data by a single researcher working in the area were considered limitations.

Aiming for consensus can obscure significant differences in perspectives and suppress minority opinions, with a tendency for experts holding extreme views to withdraw (Keeney, Hasson and McKenna, 2011). In the present study, there was an attrition of five experts from the first to the second round one to round two and the loss of an additional expert in the third round. An analysis of the responses of the pharmacist who did not complete round three reveals they expressed only one extreme 'strongly' response in the second round, agreeing with the statement, 'The biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers.' This opinion diverged from the overall consensus; however, had they participated in the third round and maintained the same response, the consensus disagreement with the statement would have decreased from 75% to 73%, yet still exceeded the 70% threshold.

The attrition of experts during the Delphi process can potentially impact the final consensus. In this study, the withdrawal of six experts across the rounds may have influenced the results. It is important to consider the potential reasons for expert withdrawal, such as time constraints, loss of interest or disagreement with the direction of the consensus. Future studies could benefit from implementing strategies to minimise attrition, such as shorter questionnaires, more frequent reminders or personal follow ups.

One of the limitations of this study was the size and composition of the panel. Although the number of participants initially recruited and those who completed all rounds was appropriate for the adopted Delphi methodology and exceeded the minimum target established at the study's outset, the panel size remained relatively modest compared to other studies reviewed in the literature. Furthermore, despite efforts to ensure comprehensive representation of the pharmacy profession in Wales, the absence of an expert pharmacist from the pharmaceutical industry may have influenced the study's outcomes. This is evident in the priorities identified for the profession's future, as the utilisation of technology and AI for drug discovery and development was not deemed a high priority by the panel. Additionally, there was a high proportion of responses from individuals employed within the NHS managed sector, which includes hospital and primary care pharmacists. This may be attributed to their pre-existing professional relationships with the researcher and their willingness to assist a peer in this study.

The research may also be subject to participant selection bias, as pharmacists with a pre-existing interest or enthusiasm for digital technology and AI may have been more likely to engage fully with all Delphi rounds. This self-selection could potentially skew the results towards more favourable views on technological innovation, limiting the generalisability of the findings. Consequently, extrapolating the expert panel's perspectives to the wider pharmacist population in Wales presents challenges. To address this limitation, a comprehensive workforce survey could be conducted to assess the extent to which these expert views align with those of the broader pharmacy community. The survey could be distributed either to all 2,764 pharmacists registered in Wales (Appendix t) or through a stratified random sampling approach, as demonstrated by Blease *et al.* (2018), whose GP survey accounted for demographic variables such as gender, age and sector to ensure a statistically valid representation of the broader profession. This method would allow for the derivation of generalisable inferences from the sample to the parent population (Newell and Burnard, 2011).

Extending the research to include the broader pharmacy workforce in Wales also presents an opportunity to adopt a holistic socio-technical perspective, which examines the complex

interactions between people, processes and digital systems. This approach recognises that the success of technology adoption depends not only on system design and functionality but also on how these systems are embedded within social and organisational contexts (James *et al.*, 2013b; Harvey *et al.*, 2012).

Furthermore, expanding the study to include pharmacy technicians and support staff would enable a more inclusive understanding of how digital technologies are perceived and utilised across the pharmacy team. It is possible that their perspectives may differ from those of pharmacists, particularly concerning role security and job displacement, issues previously observed in automation studies (Crawford *et al.*, 1998; James *et al.*, 2013). These studies noted that pharmacy technicians expressed greater apprehension about automation, often perceiving it as a threat to their roles. Although fear of job loss was not always explicitly stated, anxiety about robots assuming routine responsibilities was clearly implied. Applying a socio-technical lens to the experiences of these other staff could reveal important unintended consequences, such as role conflict, workflow disruption or increased workload, arising from poorly implemented digital tools (as observed by Van der Meer *et al.*, 2013). Therefore, applying this approach to the Welsh context could generate actionable insights for policy and pharmacy practice, supporting more inclusive, equitable and context-sensitive strategies for digital transformation across the pharmacy workforce.

An evident shortcoming of this healthcare study is the exclusion of the patient's perspective. Patient-Centered Outcomes Research is important to empower patients and caregivers within the research process by integrating their perspectives and experiences (Al Hamarneh *et al.*, 2020). Patients can collaborate to identify priorities, design protocols and ensure data integrity, thereby enhancing research projects through improved shared decision-making, addressing health disparities, and advancing healthcare quality and cost-effectiveness (Adesanoye and Guirguis, 2017; Bailey *et al.*, 2021). Further collaborative research with patients could yield valuable insights into patient preferences, concerns and expectations regarding AI and technology integration in pharmacy services. It could also help identify potential patient-orientated barriers to adoption, such as concerns about privacy, data security, accessibility, digital exclusion or the human touch in healthcare.

In the context of the development and implementation of technology in pharmacy in Wales, it is important to acknowledge the involvement of additional stakeholders who could be considered in future studies. These stakeholders may encompass software developers, healthcare administrators, policymakers, and medical device manufacturers. Their perspectives and expertise could offer valuable insights into the challenges and opportunities associated with the incorporation of new technologies in healthcare. Future research that incorporates these diverse viewpoints may contribute to a more comprehensive understanding of effective strategies for integrating technology into pharmacy practice in Wales, addressing not only the technical aspects but also the broader systemic, regulatory, and practical considerations that influence successful implementation and adoption.

As a practitioner-researcher working in the field and with inherent enthusiasm about the use of technology and AI in pharmacy, there is a concern about being too close to the subject and steering positive opinions and findings from the research. It was important to be mindful of the potential for unintentional bias that could arise during any stage of the research by being an insider, particularly during thematic analysis of the expert responses from round one and the subsequent statement development for the following rounds. To mitigate this potential for bias, a thorough and iterative process was followed for the qualitative analysis to allow the themes and subsequent codes to emerge from the data itself (Gordon and Pease, 2005).

There are other limitations common to Delphi studies, including the lack of standardised guidance for their conduct and criticism of the use of digital technology for communication with the participants which may limit the richness of debate that would occur through face-to-face panel discussions (Jaam *et al.*, 2000). Gargon *et al.* (2019) raise concerns about low response rates and high attrition of panellists, which can reduce validity of the results and increase bias if participants with minority opinions drop out the study, although this issue was not apparent in this study. There are known limitations with the generalisability and replicability of the opinions of the experts to the wider population or the reliability of the findings from a small number of selected experts in one country to other countries and different regions around the world (Hasson, Keeney and McKenna, 2000). Furthermore, the

accuracy of the forecasts cannot be guaranteed, although other Delphi researchers have demonstrated some positive future predictions through rerunning their surveys after many years (Ono and Wedemeyer, 1994).

5.7.3 Further Research

Despite these limitations, the study gained consensus agreement by the panel on the majority of the statements presented to them and the findings offer useful insights and recommendations for the pharmacy profession in Wales. The survey questions covered a diverse range of topics and to expand on these results, further detailed examination of some of the topics could be undertaken through individual interviews.

Future collaborative research in AI with pharmacists could focus on the development of ethical, transparent and patient-centred AI tools tailored to the specific demands of pharmacy practice. These tools should aim to enhance clinical decision-making, support personalised treatment plans and improve patient outcomes, while maintaining accountability, equity and adherence to professional and regulatory standards. Involving pharmacists actively in the design, testing and implementation stages can help ensure that these technologies are both clinically relevant and trusted by the end-users. Additionally, incorporating ethical frameworks and regulatory oversight from the beginning will be crucial to addressing issues related to bias, data privacy and confidence in AI-generated recommendations within real-world pharmacy settings.

As outlined in the previous section, broadening the scope of the study to include the wider pharmacist population, as well as pharmacy technicians and support staff, would provide a more comprehensive and inclusive understanding of how digital technologies are perceived, experienced and integrated across the pharmacy workforce in Wales.

Comparator studies could be conducted in different countries to determine if the perspectives and future priorities for technology and AI in pharmacy among experts based in a small European nation are distinct from those in other countries and healthcare systems. Additionally, researchers could consider adopting a longitudinal design to assess the reliability

of the study findings and track changes in attitudes and concerns over time as AI becomes more integrated into pharmacy practice (as suggested by Hasson, Keeney and McKenna, 2000). As a pharmacy practitioner, it would be particularly intriguing to consider revisiting the study outcomes in 2030 or even by 2050 to test the predictions. However, it is acknowledged that this responsibility may need to be entrusted to other pharmacy researchers in the field by that later date.

5.8 CHAPTER SUMMARY

In this chapter the findings from the study have been discussed and compared with existing literature. This study has provided valuable insights into the future of pharmacy in Wales, highlighting the potential for significant technological advancements by 2030 and beyond.

In summary, the panel predictions for pharmacy in Wales by 2030 include the implementation of a shared medication record, automated dispensing and the widespread use of AI in education and clinical validation of prescriptions, far surpassing current objectives. Key future priorities include the development of a comprehensive digital health record and the application of AI for data analysis, performing clinical checks and optimising prescribing through genomic profiling.

While pharmacists generally view these advancements positively, recognising their potential to enhance decision-making and patient care, concerns about digital skills within the profession have been identified. The study finds that in order to fully realise the benefits of emerging technologies in healthcare, it is crucial to address implementation barriers, allocate funding for digital innovation and capitalise on the interconnected healthcare system in Wales. Moving forward, strong leadership, a clear strategy and active engagement of pharmacists in digital design will be essential to build trust and confidence in technology and AI, ultimately transforming pharmacy practices and improving patient outcomes in Wales.

The chapter also highlighted the key strengths of this research study, such as a high response rate, low attrition rate and inclusion of participants from diverse pharmacy sectors. The piloting process carried out for each round of the study ensured the content and face validity

of the surveys. The chapter also acknowledged some limitations of the research due to constraints on time and researcher capacity, and it detailed the measures taken to minimise any potential bias that might have influenced the results.

The following chapter will summarise the study's findings, reflect on its contribution to literature and offer recommendations to the pharmacy profession and wider healthcare organisation in Wales.

Chapter 6. Conclusion

6.1 INTRODUCTION

The concluding chapter to this thesis provides a comprehensive summary of the key findings from the study. It presents a set of recommendations for the pharmacy profession and wider stakeholders in Wales. Finally, it details the strategy for disseminating the research outcomes and culminates with concluding remarks on the personal benefits of this doctoral journey.

6.2 STUDY SUMMARY

This study uses a three-round E-Delphi method to critically explore the opinions of pharmacy leaders in Wales on the impact of digital technology, automation and AI on contemporary pharmacy practice. The first objective was to review existing research on pharmacists' opinions in this field. The literature review highlighted a lack of studies in the UK that specifically address pharmacists' viewpoints. As a result, the study seeks to collect insights from pharmacy professionals about the application of digital health technology in pharmacy, its impact on the workforce and the potential challenges and facilitators associated with such technology in Welsh pharmacy practice. The Delphi technique has been chosen to gather expert consensus, given the limited existing knowledge on the topic and the lack of published research related to pharmacists.

With contribution from 38 pharmacist experts across various sectors of practice in Wales, a consensus agreement has been reached on 31 of the 39 Likert-scale questions. The ranking questions provide consistent priorities for areas that require future development in pharmacy.

6.3 KEY FINDINGS

The panel forecast that by 2030, dispensing will be fully automated, and a shared medication record will be available across Wales. They predict that by 2030, AI will be used in pharmacy education, medicines information and clinical validation of prescriptions. By 2050, the panel prioritise access to a single digital health record and confirm the significant potential of medical wearable technologies in pharmacy. The study reveals the importance of AI-enabled

tools for data analysis to support clinical pharmacy and advancements in pharmacogenomics for individualised patient care.

The experts predominantly express optimistic attitudes towards the integration of digital health technology and AI within their practice, expressing little concern about potential role displacement. This sentiment is consistent with the positive outcomes reported in the pharmacist studies included in the literature review (Mehta and Onatade, 2008; James *et al.*, 2013b; Mills, Weidmann and Stewart, 2017; Rodriguez-Gonzalez *et al.*, 2018; Grammatikopoulou *et al.*, 2024; Gustafson *et al.*, 2024; Syed and Al-Rawi, 2024) and aligns with the research conducted by Blease *et al.* on GPs (Blease *et al.*, 2018; Blease *et al.*, 2019), which were the original studies that inspired this research project. The panel believe that technology will assist, rather than replace, pharmacists in making clinical decisions. Pharmacists will continue to be essential for providing expert oversight of AI-enabled tools and offering important interactions with patients who require their care.

The panel advocated for the establishment of specialised clinical informatics pharmacist roles, while simultaneously raising concerns regarding the broader issue of digital literacy and expertise within the profession. These findings are consistent with the studies of pharmacists from other countries, where inadequate knowledge and skills relating to emerging technologies such as AI have been identified as barriers to progress (Hogan-Murphy *et al.*, 2021; Alghamdi *et al.*, 2022; Jaber *et al.*, 2024)

The research uncovered some obstacles to the implementation of digital health technology in Wales. These included issues with system integration and connectivity, as well as the failure of previous projects and funding constraints. However, there were positive advantages in relation to the national digital infrastructure, small system networks and the ability to trial and scale up projects rapidly. These findings were specific to Wales but could also be beneficial to other smaller countries with rural populations.

The study found strong pharmacy leadership within Wales, with the positive advantages of a clear supportive strategy that promotes a culture of innovation in pharmacy and ensures

pharmacists are at the forefront of digital transformation, harnessing the benefits of technology for healthcare in the future.

The data indicated some differences in opinions among various groups of pharmacists. Notably, pharmacists working in the community sector expressed a more favourable attitude towards the widespread use of AI and roll out of automated dispensing to all sectors in the near future. However, younger pharmacists demonstrated greater scepticism regarding the pace of advancements in technology and AI in pharmacy the rapid progression of technological advancements and AI integration within the field of pharmacy. Figures 75 and 76 summarise the key findings from the study.

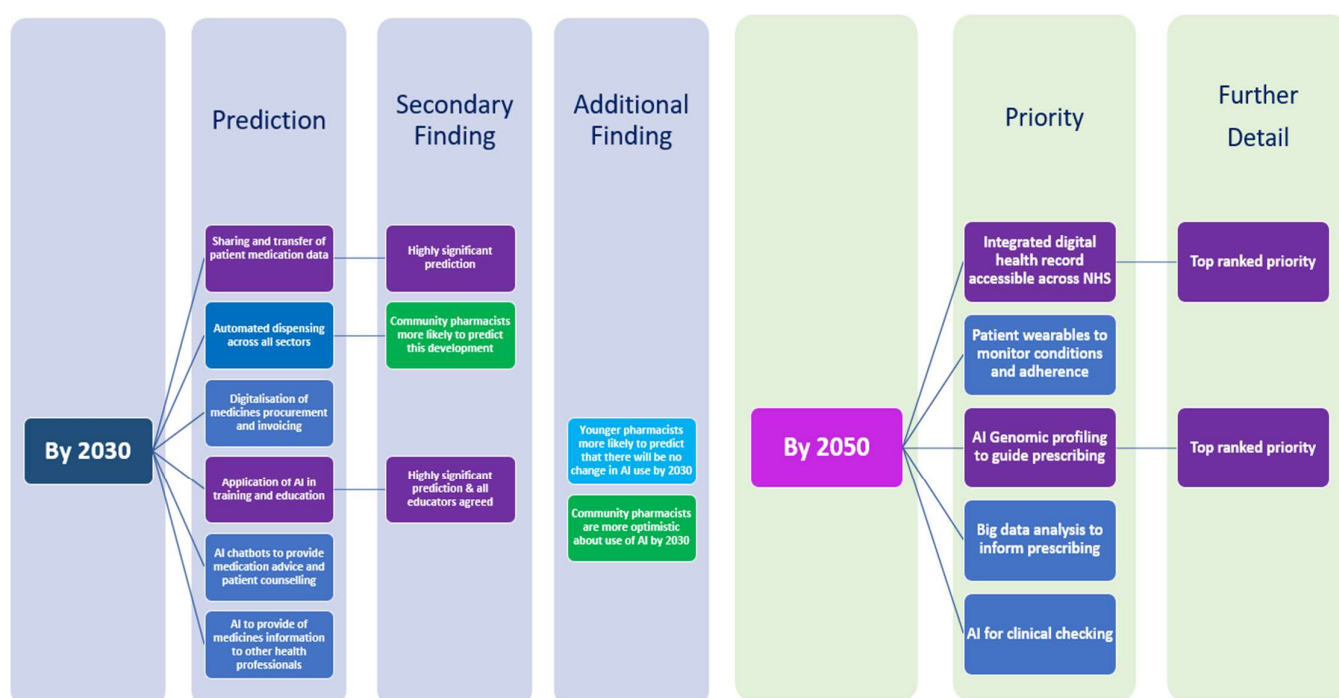


Figure 75. Expert predictions for 2030 and priorities for 2050 for the use of digital technology, automation and AI in pharmacy in Wales.

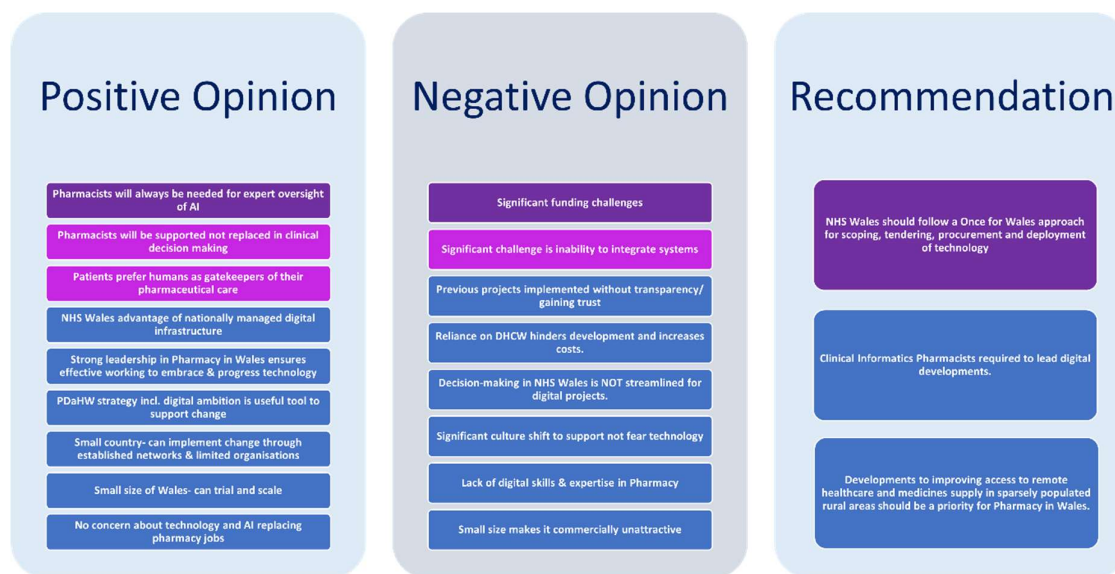


Figure 76. Expert opinions of factors affecting the implementation of technology in pharmacy in Wales.

6.4 CONTRIBUTION TO RESEARCH

This study's unique contribution lies in its exploration of pharmacists' short-term predictions regarding digital technologies and AI, alongside identifying long-term technological priorities specific to Wales. The study amplifies the perspectives of Welsh pharmacists, revealing their readiness, concerns and aspirations in the context of digital transformation of pharmacy practice. By focusing on both immediate and long-term technological impacts, the study provides a comprehensive foundation for strategic planning and policy development. This forward-looking approach can help stakeholders in the Welsh pharmacy sector prepare for and adapt to upcoming technological change enhance patient care and service delivery.

6.5 RECOMMENDATIONS

In summary, there are a number of recommendations for different stakeholders that have emerged from the research project.

One of the most significant findings throughout the study was the necessity to develop the digital literacy and expertise of the pharmacy workforce. It is suggested that education providers, employers and pharmacy professional bodies collaborate to facilitate and promote the development of these essential skills through undergraduate programmes and post-

registration learning opportunities. To ensure that pharmacy students and professionals are well-prepared to face the challenges of healthcare in the future, educators are advised to integrate emerging AI technology into their teaching to a greater extent.

Moreover, it is crucial for the pharmacy workforce to acquire a comprehensive understanding of the principles of AI, its capabilities and limitations. This will equip them with the necessary skills and judgement to assess the quality of AI-enabled tools and determine the appropriate application in their practice. This can be achieved through the provision of continuous professional development opportunities, bespoke pharmacy courses and access to national digital skills training programmes.

While it is ultimately incumbent on employers to recognise the worth of digital skills and provide the necessary resources for training, there are steps that individuals can take to enhance their prospects of obtaining funding. The pharmacy profession can play a role in facilitating these steps by offering mentorship, guidance and providing networking opportunities that enable individuals to gain valuable insights from those who have successfully secured financial support for their training. Pharmacy in Wales should foster a supportive culture that facilitates digital transformation and continue to provide strong strategic leadership through the professional body and other national committees.

Pharmacy and medical researchers should conduct research to demonstrate the accuracy of AI-enabled tools in pharmacy, such as chatbots, medical wearables and clinical decision support systems. These studies are essential for generating robust evidence that demonstrates enhanced medication usage and improved patient outcomes, thereby increasing trust and acceptance of these technologies among pharmacy professionals in the future. Academic pharmacy will need to be resourced sufficiently to deliver both research and education aligned with future needs.

Digital Health and Care Wales (DHCW) should establish effective communication channels with stakeholders, including pharmacists and other healthcare professionals, to facilitate their understanding of the organisation's scope of work and to set realistic expectations.

DHCW should prioritise the implementation of the Shared Medicines Record, ensuring that pharmacist access is a fundamental component. Furthermore, it is essential for DHCW to engage pharmacists in the development and decision-making processes concerning the digital health record and any future digital implementation programmes in NHS Wales. Technological innovation must consider human factors by involving pharmacists and patients early in system design, tailoring digital tools to clinical workflows and establishing feedback loops to optimise adoption. This participatory approach can help ensure that future digital health solutions are developed to meet the evolving needs of patients and healthcare providers alike.

Governmental and health organisations must drive digital health advancement through sustained investment and support. This includes allocating resources for research, development and implementation of innovative solutions; creating supportive policy frameworks; and streamlining regulatory processes. Collaborative working with all healthcare professionals is essential for successful digital transformation. Future policymakers should explicitly incorporate pharmacy representation into national digital health initiatives to ensure that the unique needs and opportunities for pharmacists are adequately addressed. In a small, networked nation with a national digital infrastructure, there's an opportunity in Wales to implement and test innovative approaches rapidly, potentially serving as a model for larger-scale implementations.

6.6 DISSEMINATION OF THE FINDINGS

The findings of the study will be summarised and distributed to the expert panel members who expressed an interest in receiving the study report. The research recommendations will be presented to the Welsh Pharmaceutical Committee and Welsh Directors of Pharmacy Group. Abstracts will be submitted to the Royal Pharmaceutical Society's Conference and the Health Services Research and Pharmacy Practice Conference. With guidance from the research supervisors on appropriate journals, the findings will be prepared and submitted for publication. The researcher has also been invited to join the 'Pharmacy, Data and AI' group set up by DHCW in Wales and has presented the findings of this study at the inaugural meeting.

6.7 FINAL PERSONAL REFLECTION

One of the advantages of a professional doctorate, such as the Doctorate of Professional Practice, is that the knowledge is generated within the candidate's own professional field and can subsequently be used to influence the future delivery of that professional practice (Boud *et al.*, 2018). The findings from this study will be presented to the Welsh Pharmaceutical Committee and other professional pharmacy organisations and is expected to have an impact the planning of pharmacy in Wales, shaping the future direction of pharmacy policy and education and promoting evidence-based pharmacy practice.

Another reason for pursuing a professional doctorate is that it enables candidates develop the ability to conduct research within their own professional context (Boud *et al.*, 2021). The taught modules prepared me for the research project, and I hope that this thesis will demonstrate the knowledge and skills I have acquired in my research topic, as well as the growth in competence in my research abilities throughout the programme. The part-time nature of the degree course has provided me with the opportunity to conduct research at a higher level while maintaining my profession as a pharmacist. It has been a highly rewarding experience.

My appointment as vice-chair of Pharmacy Research Wales would not have been possible without pursuing this doctoral degree. One of my aims during my tenure is to collaborate with other researchers to develop innovative solutions that improve patient outcomes and advance the field of pharmacy research. Additionally, I aim to support other pharmacists at all stages of their careers to participate in research, through the provision of support, resources and mentorship.

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Appendices

Appendix a. Search Strategies

Searches last conducted 01/06/2024

	Ovid MEDLINE(R) ALL	
1	exp Pharmacists/	23380
2	(pharmacist* or pharmacy).tw.	85422
3	1 or 2	88631
4	exp Artificial Intelligence/	217333
5	exp Machine Learning/	81204
6	exp Natural Language Processing/	7428
7	exp Decision Support Systems, Clinical/	10147
8	exp Automation/	69819
9	exp Digital Technology/	1255
10	(artificial intelligence or AI).tw.	92547
11	machine learning.tw.	115718
12	natural language processing.tw.	8829
13	clinical decision support system*.tw.	3469
14	automation.tw.	19847
15	digital technology.tw.	3494
16	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15	403816
17	3 and 16	1318
18	limit 17 to english language	1274
19	limit 18 to dt=19460101-20240601	1149

	Ovid Embase	
1	exp Pharmacists/	106473
2	(pharmacist* or pharmacy).tw.	175548
3	1 or 2	204658
4	exp artificial intelligence/	121897
5	exp Decision Support Systems, Clinical/	7982
6	(artificial intelligence or AI).tw.	116759
7	machine learning.tw.	134307
8	natural language processing.tw.	10680
9	clinical decision support system*.tw.	4260
10	automation.tw.	27043
11	digital technology.tw.	3910
12	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	336448
13	3 and 12	2157
14	limit 13 to english language	2044
15	limit 14 to dc=19740101-20240601	1778

	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S16	S14 AND S15	606
S15	EM 19920101-20240601	7,126,069
S14	S3 AND S12	696
S13	S3 AND S12	707
S12	S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11	70,379

S11	TI "digital technology" OR AB "digital technology"	1,392
S10	TI automation OR AB automation	3,255
S9	TI "clinical decision support system*" OR AB "clinical decision support system*"	1,559
S8	TI "natural language processing" OR AB "natural language processing"	2,455
S7	TI "machine learning" OR AB "machine learning"	16,168
S6	TI ((artificial intelligence or AI)) OR AB ((artificial intelligence or AI))	20,620
S5	(MH "Decision Support Systems, Clinical")	7,249
S4	(MH "Artificial Intelligence+")	38,268
S3	S1 OR S2	48,753
S2	TI ((pharmacist or pharmacy)) OR AB ((pharmacist or pharmacy))	43,097
S1	(MH "Pharmacists")	19,246

	Cochrane Database of Reviews (Wiley)	
ID	Search	Hits
#1	MeSH descriptor: [Pharmacists] explode all trees	1146
#2	(pharmacist* or pharmacy)	26073
#3	#1 OR #2	26073
#4	MeSH descriptor: [Artificial Intelligence] explode all trees	3437
#5	MeSH descriptor: [Decision Support Systems, Clinical] explode all trees	693
#6	("artificial intelligence" or AI)	13197
#7	"machine learning"	3287
#8	"natural language processing"	299
#9	"clinical decision support system"	577
#10	automation	1279
#11	"digital technology"	474
#12	{OR #4-#11}	20687
#13	#3 AND #12	123

Additional search strategies **02/06/2024- 10/01/2025**

	Ovid MEDLINE(R) ALL <1946 to January 06, 2025>	
1	exp Pharmacists/	23454
2	(pharmacist* or pharmacy).tw.	85806
3	1 or 2	89015
4	exp Artificial Intelligence/	220084
5	exp Machine Learning/	83085
6	exp Natural Language Processing/	7527
7	exp Decision Support Systems, Clinical/	10186
8	exp Automation/	70191
9	exp Digital Technology/	1311
10	(artificial intelligence or AI).tw.	94315
11	machine learning.tw.	118189
12	natural language processing.tw.	8978
13	clinical decision support system*.tw.	3505
14	automation.tw.	19984
15	digital technology.tw.	3560
16	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15	409211
17	3 and 16	1332
18	limit 17 to english language	1288
19	limit 18 to dt=20240602-20250110	127
	Ovid Embase <1974 to 2025 Week 01>	
1	exp Pharmacists/	106982

2	(pharmacist* or pharmacy).tw.	176268
3	1 or 2	205548
4	exp artificial intelligence/	124829
5	exp Decision Support Systems, Clinical/	8136
6	(artificial intelligence or AI).tw.	119520
7	machine learning.tw.	137138
8	natural language processing.tw.	10866
9	clinical decision support system*.tw.	4305
10	automation.tw.	27227
11	digital technology.tw.	3970
12	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	342733
13	3 and 12	2200
14	limit 13 to english language	2086
15	limit 14 to dc=20240602-20250110	309

	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S16	S14 AND S15	52
S15	EM 20240602-20250110	136,890
S14	S3 AND S12	700
S13	S3 AND S12	711
S12	S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11	71,374
S11	TI "digital technology" OR AB "digital technology"	1,411
S10	TI automation OR AB automation	3,380
S9	TI "clinical decision support system*" OR AB "clinical decision support system*"	1,581
S8	TI "natural language processing" OR AB "natural language processing"	2,506
S7	TI "machine learning" OR AB "machine learning"	16,486
S6	TI ((artificial intelligence or AI)) OR AB ((artificial intelligence or AI))	21,053
S5	(MH "Decision Support Systems, Clinical")	7,270
S4	(MH "Artificial Intelligence+")	38,534
S3	S1 OR S2	48,350
S2	TI ((pharmacist or pharmacy)) OR AB ((pharmacist or pharmacy))	42,669
S1	(MH "Pharmacists")	19,339

Cochrane Database of Reviews (Wiley)		
#1	MeSH descriptor: [Pharmacists] explode all trees	1148
#2	(pharmacist* or pharmacy)	26185
#3	#1 OR #2	26185
#4	MeSH descriptor: [Artificial Intelligence] explode all trees	3453
#5	MeSH descriptor: [Decision Support Systems, Clinical] explode all trees	695
#6	("artificial intelligence" or AI)	13342
#7	"machine learning"	3320
#8	"natural language processing"	302
#9	"clinical decision support system"	587
#10	automation	1284
#11	"digital technology"	482
#12	{OR #4-#11}	20892
#13	#3 AND #12	409
02/06/2024-10/01/2025 9		

Appendix b. Summary table/ Characteristics of the included studies

Author (year), country	Technology	Sector	Setting	Study design/ method	Participants	Research aim	Outcomes/ key findings or themes
Crawford <i>et al.</i> (1998), US.	Automation	Hospital	1 hospital	Cross sectional, questionnaire	70 pharmacists (147 pharmacy staff in total).	Attitudes use of robots before implementation	Favourable attitudes overall. Positive about job security, professional impact, robotics orientation. Pharmacy technicians most negatively affected.
Afolabi and Oyeibisi (2007a), Nigeria.	Automation	Hospital	3 hospitals	Cross sectional, questionnaire	53 pharmacists	Perceptions of possible barriers to automation in hospital	Most show some proficiency in computing & automation concepts. Low proficiency= more barriers. Fears about feasibility, threat to jobs, funding, management commitment, infrastructure. Benefits release from dispensing, more clinical time.
Afolabi and Oyeibisi (2007b), Nigeria.	Automation	Hospital	3 hospitals	Cross sectional, questionnaire	53 pharmacists	Attitudes toward the introduction of automation	Good understanding of automation. Positive impact on dispensing, inventory management, admin, pharmaceutical care. Need appropriate training and education
James <i>et al.</i> (2013b), UK.	Automation	Hospital	1 hospital	Longitudinal, mixed methods case study	Questionnaire pre-automation (14 pharmacists, total 35 pharmacy staff) post-automation (3 pharmacists, total 16 pharmacy staff). Post automation focus group- 17 pharmacists (total 31 pharmacy staff)	Impact of automation on staff experience of workplace stressors	Positive impact on stress, workload, environment, role expansion. Negative for technicians. New concern of robot malfunction.
Rodriguez-Gonzalez <i>et al.</i> (2018), Spain.	Automation	Hospital	1 hospital	Cross sectional, questionnaire	8 pharmacists (17 pharmacy staff in total)	Does robotic dispensing improve patient safety, inventory management and staff satisfaction in outpatient hospital pharmacy	Positive impact on staff satisfaction, esp. robot replenishment, dispensing software, safety, stock management.
Van Der Meer <i>et al.</i> (2013), UK.	Automation	Hospital	4 hospitals	Descriptive, qualitative, unstructured interviews	36 pharmacy staff in total	Early-stage experiences of large-scale automation and centralisation of medicines distribution	Issues with robotic storage & distribution system, sourcing unavailable medicines. Also understanding of new roles, importance of effective communication, effect on staff morale.
Ramachandram <i>et al.</i> (2024), Malaysia.	Automation	Hospital	1 hospital	Cross sectional, questionnaire	21 pharmacists (39 pharmacy staff in total)	Impact of automation on workload and staff satisfaction in inpatient	81% pharmacists confident in system. Beneficial for patients, reducing medication errors. Reduced workload in medication handling, achieved user satisfaction.
Cavaco and Krookas (2014), Portugal.	Automation	Community	10 pharmacies	Cross sectional, mixed methods, quasi-experimental	42 pharmacists (68 pharmacy staff in total)	Impact of automation on patient interaction length & job satisfaction	Automation had no significant influence on patient interaction duration or job satisfaction.

Mehta and Onatade (2008), UK.	Digital- e-prescribing	Hospital	7 hospitals	Descriptive, qualitative, semi-structured telephone interviews	7 pharmacists	Experiences of staff with inpatient e-prescribing systems	Positive benefit, enhanced patient safety, patient prioritisation. Concerns about reduced patient contact, training and staff for implementation.
Mills, Weidmann and Stewart (2017), UK.	Digital- e-prescribing	Hospital	1 hospital	Descriptive, qualitative, semi-structured interviews	6 pharmacists (19 HCP in total)	Hospital staff views of prescribing and discharge communication pre & post e-prescribing implementation	Well-received overall. Benefits- clarity & accuracy of inpatient charts & discharge info, improved prescriber confidence. Issues with senior staff resistance.
Hogan-Murphy <i>et al.</i> (2021), Ireland.	Digital- e-prescribing	Hospital	3 hospitals	Descriptive, qualitative, semi-structured interviews	4 pharmacists (21 healthcare staff in total)	HCP's perceptions of the facilitators & barriers to implementing e-systems for medicines management	Key facilitators- enhanced patient safety and efficiency, clinical champions, multi-disciplinary implementation team to promote engagement. Key barriers- inadequate training & organisational support, need for ease and confidence in system.
Grammatikopoulou <i>et al.</i> (2024), Greece.	Digital- e-prescribing	Multi	National	Cross sectional	137 pharmacists (430 HCP in total)	HCP's perceptions of e-prescribing system	Overall HCP were positive. For pharmacists, 88% positive impact on work routine, 81% easy to use, 80% easy to learn, 70% system clear & comprehensible. System convenient & secure. Issue with lack of dosage, allergies & ADR info.
Mercer <i>et al.</i> (2018), Canada.	Digital- EHR	Community	19 pharmacies (& medical clinics)	Descriptive, qualitative, semi-structured interviews	25 pharmacists (34 HCP in total)	Examine how HCPs understand & communicate patient-focused medication information & influence on HER design	Interprofessional Shared Decision-Making not occurring. Indirect Communication, incomplete Information, separate EHRs do not facilitate collaboration.
Kosari <i>et al.</i> (2020), Australia.	Digital- EHR	Multi	National	Cross sectional	63 pharmacists	Perspectives of potential benefits & barriers associated with My Health Record	Overall satisfaction varied. Perceived benefits- 90% continuity of care, 71% medication safety, 75% higher quality of care, 57% reduce dispensing errors, 57% improve professional relationships with patients and GPs. Potential barriers- 81% patients' privacy, training, system access, 66% data accuracy, 44% security.
Tolley <i>et al.</i> (2023), UK	Digital- EHR	Multi	Various. 1 region	Qualitative, semi-structured interviews	21 pharmacists (23 HCP in total)	Scope what systems transfer medicines information across care interfaces, challenges & opportunities	Multiple, complex medicines management systems being used. Transfer of care issues, incomplete patient records, lack of interoperability, poor IT & change management. Clear need for patient-centered consolidated integrated HER.
Hines <i>et al.</i> (2011), US.	Digital- CCDS	Multi	Various	Descriptive, qualitative, unstructured interviews	61 pharmacists	Awareness of DDI & medication-related CDS features in pharmacy information systems	All systems provided drug-allergy and DDI alerts. 60% recommendations for managing drug interactions. 40% issues with excluded drugs on system. Overall, limited awareness of all decision support functionalities. More training about software capabilities required.
Wathoni <i>et al.</i> (2023), Indonesia.	Digital- telehealth	Multi	National	Cross sectional	378 pharmacists	Assess level of knowledge, perception & readiness toward telepharmacy	97% high level of knowledge, 63% readiness for telehealth
Alghamdi <i>et al.</i> (2022), Saudi Arabia.	Digital- telehealth	Multi	National	Cross sectional	112 pharmacists (1034 HCP in total)	Explore use of telehealth by HCP & their attitudes, perceptions & barriers	47% of HCP and 62% pharmacists use telehealth. 44% HCP say telehealth increases care quality, 43% comfortable using. 45% useful for patient access. Barriers- time (38%), internet connection (36%), trained staff (36%).

Abu Hammour <i>et al.</i> (2023), Jordan.	AI	Multi	National	Cross sectional	359 pharmacists	Knowledge and usage of ChatGPT in pharmacist practice	70% useful for education & marketing. 56% concerns response bias & accuracy. Statistically significant association between increase use of ChatGPT use & positive perceptions.
Jaber <i>et al.</i> (2024), Middle East	AI	Multi	National	Cross sectional	328 pharmacists	Knowledge, attitudes & practices regarding AI	49% positive attitudes. 45% moderate knowledge. 48% no exposure. 57% improve clinical practice. 42% will not replace HCP.
Jairoun <i>et al.</i> (2024), UAE.	AI	Multi	Various	Descriptive, qualitative, semi-structured interviews	35 pharmacists	Perspectives on benefits & risks of using ChatGPT	Benefits- enhance compliance, use, management, safety, adherence to medication, medication counselling, minimise medication errors, and streamline medication dispensing. Concerns- inaccurate recommendations, inadequate medication details, difficulty interpreting ambiguous patient input/ drug descriptions
Jarab <i>et al.</i> (2023), Jordan.	AI	Community	National	Cross sectional, questionnaire	401 pharmacists	Willingness & attitudes towards adoption of AI technology & barriers	Good willingness and attitudes. Barriers-79% lack of AI-related software and hardware (79%), 76% need for human supervision, 74% high running cost
Syed and Al-Rawi (2024), Saudi Arabia.	AI	Community	Various	Cross sectional, questionnaire	273 pharmacists	Awareness, perceptions & opinions of AI	95% aware of AI. 63% assist HCP, 69% improve HCP roles, 84% reduce drug errors, 88% aid decisions making, 86% improve patient access. 26% replace HCP, 3% concerned about jobs
Alanzi (2023), Saudi Arabia.	AI	Hospital	2 hospitals	Descriptive, qualitative, semi-structured focus groups	6 pharmacists (54 HCP in total)	Impact of ChatGPT on teleconsultants in managing operations and services	12 positive themes- incl. informational support, diagnostic assistance, communication, efficiency, personalising care, assisting in medical research, decision-making, documentation, education & team collaboration. Issues with misdiagnosis & errors, ethical & legal, limited medical context/ knowledge, communication challenges & increased dependency.
Taha <i>et al.</i> (2024), Egypt.	AI	Multi	National	Cross sectional, questionnaire	428 pharmacists	Perceptions, practices & and concerns regarding ChatGPT	74% recognise benefits, 86% regulatory compliance, 65% academic material. Concerns 66% privacy, 60% security threat, 48% accuracy, 54% bias. 30% no previous usage, 20% rarely use.
Yousif <i>et al.</i> (2024), Pakistan.	AI	Hospital	2 hospitals	Descriptive, qualitative, semi-structured interviews	6 pharmacists (25 HCP in total)	Perspectives of HCPs to AI & challenges to incorporation	Limited knowledge of regarding AI and its basics. Positive perceptions- improve efficiency, reduce workload, save time, minimise medical errors.
Gustafson <i>et al.</i> (2024), US.	AI	Multi	National	Cross sectional, questionnaire	1363 pharmacists	Perceptions & awareness of AI	83% some familiarity, 39% actual usage, 56% job reduction, 35% distrust. 64% enhance professional role and productivity.
Smetana, Postema and Smetana (2024), US.	AI	Education/ Academia	National	Cross sectional, questionnaire	446 pharmacists (actively precepting pharmacy residents & students)	Concerns and perceived benefits regarding use of AI in pharmacy education	Potential benefits for data analysis- 58%, Research & lit summation- 54% Concerns 70% quality & accuracy of AI content, 51% plagiarism. Younger pharmacists > concern about accuracy. Need for education to address AI literacy & and ethical usage.

Appendix c. Round one email to pharmacists who have already agreed to take part, sent 17.09.23.

To:

Subject: Request to help with research study: Digital technology and AI in Pharmacy

Dear _____

Thanks for agreeing to help me with my research for my doctoral degree at the University of Wales Trinity Saint David.

I am inviting experienced Pharmacists from different sectors across Wales to form a panel to participate in a 3-round online survey (Delphi study) over the next three months, to gain opinions on the future impact of digital technology and artificial intelligence (AI) on Pharmacy.

The initial survey will take 15-20 mins. It will start with a few demographic questions, followed by your opinion on digital technology and AI developments within the pharmacy context.

The second round will consist of a number of statements based on the anonymised responses collated from the initial survey. You will be asked to rate your agreement/disagreement with these statements using a Likert scale. It should take about 5-10 minutes to complete.

The third and final round will be similar, but the panel members' responses from the previous round will be shared (anonymously). Again, this should take 5-10 minutes to complete.

I assure you that all the information provided will be treated with the utmost confidentiality and used solely for research purposes.

Your help with this research is greatly appreciated, and if you are interested in participating, please access the participant information and questionnaire link below.

[Embed survey link](#)

Kind regards,

Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



Appendix d. Round one informal email to colleagues and professional contacts, sent 17.09.23.

To:

Subject: Request to help with research study: Digital technology and AI in Pharmacy

Hi ____

Hope you are well.
Could I ask you a favour please?

I am currently studying for a doctoral degree at the University of Wales Trinity Saint David and I was wondering if you would participate in a survey essential to my studies.

I am inviting experienced Pharmacists from different sectors across Wales to form a panel to participate in a 3-round online survey (Delphi study) over the next three months, to gain opinions on the future impact of digital technology and artificial intelligence (AI) on Pharmacy. To reassure you, you do not have to be an expert in technology or AI.

The initial survey will take 15-20 mins. It will start with a few demographic questions, followed by your opinion on digital technology and AI developments within the pharmacy context.

The second round will consist of a number of statements based on the anonymised responses collated from the initial survey. You will be asked to rate your agreement/disagreement with these statements using a Likert scale. It should take about 5-10 minutes to complete.

The third and final round will be similar, but the panel members' responses from the previous round will be shared (anonymously). Again, this should take 5-10 minutes to complete.

I assure you that all the information provided will be treated with the utmost confidentiality and used solely for research purposes.

Your help with this research is greatly appreciated, and if you are interested in participating, please access the participant information and questionnaire link below.

[Embed survey link](#)

Kind regards,

Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



Appendix e. Round one formal 'cold-calling' email to potential panellists unknown to the researcher, sent 17.09.23.

To:

Subject: Request to help with research study: Digital technology and AI in Pharmacy

Dear _____

I hope this email finds you well. My name is Amy Jayham. I am a Pharmacist working in Wales and a student of a doctoral degree at the University of Wales Trinity Saint David. I was wondering if you would participate in a survey essential to my studies.

I am inviting experienced Pharmacists from different sectors across Wales to form a panel to participate in a 3-round online survey (Delphi study) over the next three months. The aim of the study is to gain opinions on the future impact of digital technology and artificial intelligence (AI) on Pharmacy. To reassure you, you do not have to be an expert in technology or AI.

The initial survey will take 15-20 mins. It will start with a few demographic questions, followed by your opinion on digital technology and AI developments within the pharmacy context.

The second round will consist of a number of statements based on the anonymised responses collated from the initial survey. You will be asked to rate your agreement/disagreement with these statements using a Likert scale. It should take about 5-10 minutes to complete.

The third and final round will be similar, but the panel members' responses from the previous round will be shared (anonymously). Again, this should take 5-10 minutes to complete.

I assure you that all the information provided will be treated with the utmost confidentiality and used solely for research purposes.

Your help with this research is greatly appreciated, and if you are interested in participating, please access the participant information and questionnaire link below.

[Embed survey link](#)

Kind regards,

Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



Appendix f. Participant sheet.



Participant Information Sheet

Title of the project: A Delphi study to determine the impact of Digital Technology, Automation and Artificial Intelligence on Pharmacy in Wales

Name and email address of researcher: Amy Jayham MRPS (Amy.jayham@wales.nhs.uk)

Invitation: I am currently undertaking a research project for my Doctorate of Professional Studies degree at UWTSD. I would like to invite you to take part in this research, but please read this information first to decide whether you wish to take part or not.

Research summary: The aim of this research is to capture the expert opinions of Pharmacy leaders in Wales on the impact of digital technologies and AI on Pharmacy; particularly on future Pharmacy functions, roles, workforce and learning requirements. The research links in with the profession's 2030 goals of 'Harnessing Innovation and Technology', detailed in the long term vision, [Pharmacy: Delivering a Healthier Wales](#).

Why have you been invited to take part? You have received this invitation because you have been identified as an expert in your area of pharmacy practice in Wales.

What is a Delphi study? The Delphi technique is used to obtain consensus on the opinions of experts through a series of structured questionnaires. It is an iterative process, where the responses from the participants on the expert panel will be summarised and fed back anonymously to the group. Participants are then given the opportunity to respond again to the emerging data.

Do you have to take part? No, taking part in this research is voluntary. If you change your mind during the study, you can withdraw at any point.

What will happen if I agree to take part? After giving your consent, 3 rounds of questionnaires will follow, over a period of 3 months. The initial questionnaire should take 15-20 minutes to complete and will include the collection of some basic demographic information. The questionnaires for the subsequent rounds should take only 5- 10 minutes to complete. Questionnaires do not have to be completed in one session. Your answers can be saved and completed later. Links to the questionnaires will be emailed to you. You will be asked to respond in two weeks. Two reminders will be sent during each round and if no response is received, it will be assumed you do not want to continue to participate in the study.

Are there any disadvantages of taking part? The research should not pose any risks or disadvantages to you personally, other than some of your valuable time required to participate.

Will the information I give stay confidential? All of your responses are confidential. The information you give will be used for the research report, but your data will remain anonymous and it will not be possible to identify you from the report or any other dissemination activities. The research data will be securely stored and deleted after the study has been written up.

What will happen to the results of the research study? The research is being carried out as part of my DProf research degree. The findings may be published in journals or at conferences. If you would like to receive a summary of the research findings, please contact myself, Amy Jayham.

Who has approved the research? UWTSD Ethics Committee has approved this research.

If you have any questions or require any further information, either now or at any time during the study, please contact me via: Amy.jayham@wales.nhs.uk

By clicking the consent button below, you acknowledge:

- Your participation in the study is voluntary.
- You are 18 years of age.
- You are aware that you may choose to terminate your participation at any time for any reason.

Appendix g. List of possible qualitative questions for the first round.

In the next ten years, in your opinion, how do you think digital technology and AI will impact Pharmacy practice in Wales?

In the next ten years, in your opinion, do you think digital technology and AI can assist Pharmacy practice?

In your opinion, will Pharmacists will be fully replaced by AI in the future?

In the next ten years, in your opinion, what Pharmacy tasks/ roles will be replaced by digital technology and AI?

In the next ten years, in your opinion, what do you think the effects of digital technology and AI will be on the composition of the Pharmacy workforce?

How do you think the Pharmacy needs to respond to digital technology and AI?

What do you think Pharmacy as a profession should do to prepare for the future?

What potential applications do you foresee for digital technology and AI in Pharmacy?

What preparations can Pharmacy take to ensure the harnessing and utilisation digital technology and AI in Wales?

Are there any risks or concerns with the future use of digital technology and AI in Pharmacy?

Does Wales have an advantage or disadvantage in harnessing and utilising digital technology and AI in Pharmacy? Please explain.

What preparations should Pharmacy take to ensure digital technology and AI is implemented in Wales?

Do you think the profession is prepared for digital technology and AI?

Do you think there are any actions Pharmacy in Wales should prioritise?

Related to PDaHW 2030 Milestones;

By 2030, do you think digital technology and AI will improve or change the practice of Pharmacy in Wales?

What tasks/ roles in Pharmacy do you think could be completely replaced by digital technology or AI by 2030?

What tasks/ roles/ jobs in Pharmacy do you think could be fully replaced by digital technology and AI by 2030?

What tasks/ roles/ jobs in Pharmacy do you think could be assisted by digital technology or AI by 2030?

End with:

Do you have any other comments on the survey topic?

Appendix h. Screenshots from the round one Qualtrics survey.

 Prifysgol Cymru
Cardiff and Vale
University of Wales
Cardiff, Vale & Swansea

Where do you currently work or practice?

☐ Wales

☐ England

☐ Rest of UK

☐ Other

How many years' experience do you have in Pharmacy?

☐ 0- 5

☐ >5-10

☐ >10- 20

☐ >20

What is your area of expertise in Pharmacy?

Please tick all that apply.

☐ Community Pharmacy

☐ Hospital/ Acute Pharmacy

☐ Primary Care Pharmacy

☐ General Practice

☐ Academia/ Education

☐ Government

☐ Professional body/ Regulation

☐ Other (please give details)

Age (years)

☐ 25 or younger

☐ >25- 35

Gender

☐ Female

☐ Male

☐ Other

☐ Rather not say

<< >>



By 2030, what tasks and roles in Pharmacy do you think could be ASSISTED by digital technology and artificial intelligence?

By 2030, what tasks and roles in Pharmacy do you think could be FULLY REPLACED by digital technology and artificial intelligence?

By 2050, what other applications do you foresee for digital technology and artificial intelligence in Pharmacy?





To what extent do you think Pharmacy in Wales is prepared to be able to utilise and harness digital technology and artificial intelligence?

What concerns or risks for Pharmacy do you have with the use of digital technology and artificial intelligence?

What advantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?

What disadvantages do you think Wales has in harnessing and utilising digital technology and artificial intelligence in Pharmacy?

Thank you for taking time to complete this survey. The second round of questions will be emailed to you next month. Please feel free to add any other comments on the survey topic below.

Appendix i: Round one reminder email to all non-respondents, sent 01.10.23.

To:

Subject: Request to help with research study: Digital technology and AI in Pharmacy

Dear Colleague

I just wanted to send a little reminder about the below email I sent a couple of weeks ago.

I was asking for your help with a research project I am undertaking to gather the opinions of expert Pharmacists on the future impact of digital technology and artificial intelligence on Pharmacy.

If you are interested in participating, I am hoping to collate the results by Sunday 8th October to allow the data to be analysed and statements developed for Round Two of the study.

[Embed survey link](#)

Please let me know if you have experienced any issues/problems with the survey.

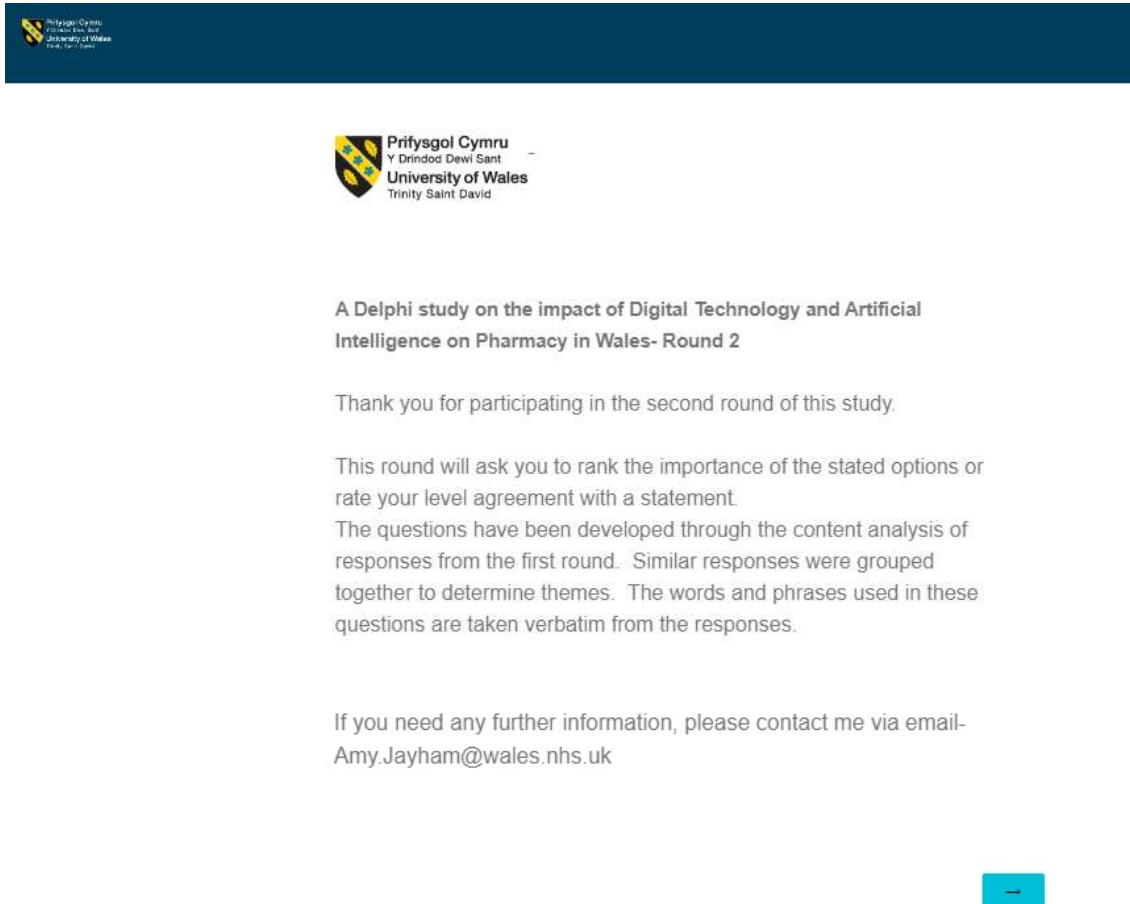
Thanks again and best wishes,

Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



Appendix j. Screenshots from the round two Qualtrics survey.





The questions below ask you to PREDICT what you think is most likely to happen, not what you would like to see.

Q1. By **2030**, digital technology and automation will be routinely used by Pharmacy in Wales...

	Very likely	Somewhat likely	Unlikely	Very unlikely
to dispense prescriptions.	☐	☐	☐	☐
for medicines procurement and invoicing.	☐	☐	☐	☐
to accuracy check dispensed medication.	☐	☐	☐	☐
to share or transfer patient medication data between healthcare providers.	☐	☐	☐	☐
to supply medicines through automated cabinets across sectors.	☐	☐	☐	☐
no more than the current situation.	☐	☐	☐	☐

Q2. By **2030**, artificial intelligence and machine learning technology will be routinely used by Pharmacy in Wales...

	Very likely	Somewhat likely	Unlikely	Very unlikely
to assist Pharmacists when clinically checking prescriptions.	☐	☐	☐	☐
to provide patient advice and counselling through chat function assistants.	☐	☐	☐	☐
to aid development, delivery and assessments for education and training.	☐	☐	☐	☐
to provide medicines information to other health professionals.	☐	☐	☐	☐
no more than the current situation.	☐	☐	☐	☐





The questions below ask you to rank what future developments would be most important to you.

Q3. Looking to the future of Pharmacy in **2050**, where do you think digital technology and automation will be most useful?

Please rank the following suggestions from the panel in order of importance to you, where 1= first choice/ priority.

Drug development and manufacturing.
Fully integrated digital health record accessed across all NHS organisations.
Monitoring patients' conditions and medication compliance through data from patient wearables and devices.
Closed loop medication supply systems (from procurement through to transportation to end user).

Q4. Looking to the future of Pharmacy in **2050**, where do you think artificial intelligence and machine learning will be most useful?

Please rank the following suggestions from the panel in order of importance to you, where 1= first choice/ priority.

Supporting pharmacies with business intelligence and workforce demand management.
Using full genomic profiling to guide optimum prescribing and generate individualised treatment plans.
Provision of medical information, literature searching and interpretation of clinical studies.
Analysis of 'big data' to inform evidence based prescribing and horizon scanning.
AI chatbots managing patient queries and providing advice.
Clinical checking of prescriptions to reduce avoidable adverse drug reactions and drug interactions.





The questions below ask you to provide your level of agreement/ disagreement with different statements developed from the first round responses.

Q5. Digital infrastructure in Wales

	Strongly agree	Somewhat agree	Disagree	Strongly disagree
NHS Wales has the advantage of a nationally managed digital infrastructure.	☐	☐	☐	☐
A reliance on DHCW being the third party organisation to provide support and expertise to implement technology hinders development and increases costs.	☐	☐	☐	☐
A significant challenge to rolling out pilot digital projects is the inability to integrate and interface with wider systems.	☐	☐	☐	☐
Previous digital projects in Wales have been implemented without transparency or gaining the trust and confidence of the profession.	☐	☐	☐	☐
NHS Wales should follow a Once for Wales approach for scoping, tendering, procurement and deployment of technology to ensure systems standardisation and interoperability.	☐	☐	☐	☐

Q6. Strategy in Wales

	Strongly agree	Somewhat agree	Disagree	Strongly disagree
In NHS Wales decision-making is streamlined and there are less hurdles in respect to governance for digital projects.	☐	☐	☐	☐
A coherent national strategy in PDaHW which includes the digital ambition for the profession, is a useful tool to support change.	☐	☐	☐	☐
Wales works in a flexible and agile approach to implementation and adoption of new technologies.	☐	☐	☐	☐
There is strong leadership in Pharmacy in Wales, allowing us work effectively as a single entity in the way we embrace and progress technology.	☐	☐	☐	☐
Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology.	☐	☐	☐	☐

Q7. Characteristics of Wales

	Strongly agree	Somewhat agree	Disagree	Strongly disagree
The size of Wales makes it less likely to be commercially attractive to system suppliers and unable influence any bespoke IT developments.	☐	☐	☐	☐
There are significant challenges funding digital developments in Wales.	☐	☐	☐	☐
The size of Wales allows us to trial advances in technology and scale up good practice rapidly.	☐	☐	☐	☐
Developments to improving access to remote healthcare and medicines supply in sparsely populated rural areas should be a priority for Pharmacy in Wales.	☐	☐	☐	☐
As a small country, Wales is able to co-ordinate and implement wide spread change through established networks and limited number of organisations	☐	☐	☐	☐

←
→



The questions below ask you to provide your level of agreement/disagreement with different statements developed from the first round responses.

Q8. Culture of Pharmacy in Wales

	Strongly agree	Somewhat agree	Disagree	Strongly disagree
The biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers.	☐	☐	☐	☐
Other professions are more willing to embrace digital tools.	☐	☐	☐	☐
A significant culture shift is required in Pharmacy to support technology rather than fear it.	☐	☐	☐	☐
Pharmacists are too risk adverse to embrace new technology.	☐	☐	☐	☐
Pharmacy has poor vision for the business change that technology enables.	☐	☐	☐	☐
Community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies.	☐	☐	☐	☐

←
→



Q9. Workforce and skills

	Strongly agree	Somewhat agree	Disagree	Strongly disagree
Pharmacists will always be needed to provide expert oversight of AI programmes and systems.	☐	☐	☐	☐
There is a lack of digital skills and expertise across Pharmacy.	☐	☐	☐	☐
AI cannot replicate the importance of Pharmacy staff interacting with patients to determine if a patient is taking their medicines correctly.	☐	☐	☐	☐
Clinical Informatics Pharmacists are required to lead digital developments.	☐	☐	☐	☐
The aging demographic of some staff groups in Pharmacy is hampering the implementation of technological developments.	☐	☐	☐	☐
Pharmacists will be supported not replaced in their clinical decision making.	☐	☐	☐	☐
Patients will always prefer humans as gatekeepers of their Pharmaceutical care.	☐	☐	☐	☐

Thank you for completing the questionnaire. The final round of questions will be sent out next month. Please feel free to add any other comments on the survey topic below.



Appendix k. Round two email to participants who completed first round, sent
23.11.23.

To:

Subject: Digital technology and AI in Pharmacy- Round Two

Dear _____

Thank you again for taking the time to participate in Round One of my Delphi study. The detailed information that I received from all the responses was tremendous.

The second round should be much quicker and simpler to complete. There are 9 sets of questions, requiring you to rank the options or rate your agreement with statements developed from the first round responses.

It should take approximately 10 minutes to finish. Questionnaires do not have to be completed in one session. Your answers can be saved and completed later. I am hoping to collate the results by **10th December 2023**. I will send two reminders before closing the survey.

Please find the link to Round 2 below:

[Embed survey link](#)

I assure you that all the information you provide will be treated with the utmost confidentiality and used solely for research purposes. If you have any questions or require any further information, please contact me via email.

Your continued help with this research is greatly appreciated.

Kind regards
Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



Appendix I. Round two reminder emails, sent 2.12.23 and 7.12.23.

To:

Subject: Digital technology and AI in Pharmacy- Round 2

Dear _____

Just sending a little reminder about the email I sent last week with the link to the second round of the Delphi study.

[Embed survey link](#)

Your continued help with this study is much appreciated.

Please let me know if you have experienced any issues/problems with this round.

Thanks again and best wishes.

Amy

Amy Jayham MRPS, MPA, Doctoral candidate.



To:

Subject: Digital technology and AI in Pharmacy- Round Three reminder

Dear _____

Just sending a final reminder about the second round of my Delphi study.

It would be great if you could complete the below survey by the 10th December please.

[Embed survey link](#)

Thanks again for your support.

Kind regards,
Amy

Appendix m. Round three email to participants who completed first round, sent 23.11.23.

To:

Subject: Digital technology and AI in Pharmacy- Round Three

Dear _____

Thank you again for your continued support with this study.

Please find the link below for the third and FINAL round!

[Embed survey link](#)

It is a much shorter questionnaire than last time with only 16 questions.

These are questions from Round 2 that did not reach a consensus of opinion. The % response from Round 2 is shown in brackets.

It should take approximately 3-5 minutes to finish.

As before, the questionnaire does not need to be completed in one session. Answers can be saved and completed later.

I am hoping to collate the results by the **8th January 2024**. I will send two reminders before closing the survey.

Hope you have a lovely Christmas!

Best wishes,

Amy

Amy Jayham MRPS, Doctoral candidate.



Appendix n. Screenshots from the round three Qualtrics survey.



A Delphi study on the impact of Digital Technology and Artificial Intelligence on Pharmacy in Wales- Round 3

Thank you for your continued support with my research.

For the final round, I will ask you to review those questions that did not reach 70% agreement of opinion in Round 2.

Again you will be required to rank the importance of the stated options or rate your level agreement with a statement.

If you need any further information, please contact me via email-
Amy.Jayham@wales.nhs.uk





The questions below ask you to PREDICT what you think is most likely to happen, not what you would like to see.

Figures in brackets show % category response in round 2.

1. By **2030**, digital technology and automation will be routinely used by Pharmacy in Wales to accuracy check dispensed medication.

☐ Very likely (15%)

☐ Somewhat likely (30%)

☐ Unlikely (49%)

☐ Very unlikely (6%)

2. By **2030**, digital technology and automation will be routinely used by Pharmacy in Wales to supply medicines through automated cabinets across sectors.

☐ Very likely (24%)

☐ Somewhat likely (49%)

☐ Unlikely (27%)

☐ Very unlikely (0)





The questions below ask you to rank what future developments would be most important to you.

Figures in brackets show % of top two choices deemed 'high priority' from round 2 responses.

3. Looking to the future of Pharmacy in **2050**, where do you think digital technology and automation will be most useful?

Please rank the following suggestions from the panel in order of importance to you, where 1= first choice/ priority.

Drug development and manufacturing (21%)
Fully integrated digital health record accessed across all NHS organisations (82%)
Monitoring patients' conditions and medication compliance through data from patient wearables and devices (70%)
Closed loop medication supply systems from procurement through to transportation to end user (27%)

4. Looking to the future of Pharmacy in **2050**, where do you think artificial intelligence and machine learning will be most useful?

Please rank the following suggestions from the panel in order of importance to you, where 1= first choice/ priority.

Supporting pharmacies with business intelligence and workforce demand management (24%)
Using full genomic profiling to guide optimum prescribing and generate individualised treatment plans (70%)
Provision of medical information, literature searching and interpretation of clinical studies (18%)
Analysis of 'big data' to inform evidence based prescribing and horizon scanning (30%)
AI chatbots managing patient queries and providing advice (15%)
Clinical checking of prescriptions to reduce avoidable adverse drug reactions and drug interactions (42%)





The questions below ask you to provide your level of agreement/ disagreement with different statements developed from the first round responses.

Figures in brackets show % category response in round 2.

5. Previous digital projects in Wales have been implemented without transparency or gaining the trust and confidence of the profession.

- ☐ Strongly agree (18%)
- ☐ Somewhat agree (52%)
- ☐ Disagree (30%)
- ☐ Strongly disagree (0)

6. Wales works in a flexible and agile approach to implementation and adoption of new technologies.

- ☐ Strongly agree (3%)
- ☐ Somewhat agree (36%)
- ☐ Disagree (55%)
- ☐ Strongly disagree (6%)

7. There is strong leadership in Pharmacy in Wales, allowing us work effectively as a single entity in the way we embrace and progress technology.

- ☐ Strongly agree (12%)
- ☐ Somewhat agree (55%)
- ☐ Disagree (24%)
- ☐ Strongly disagree (9%)

8. Acting on a 'Once for Wales' basis is a barrier to progress and slows down the adoption of technology

- ☐ Strongly agree (6%)
- ☐ Somewhat agree (30%)
- ☐ Disagree (49%)
- ☐ Strongly disagree (15%)

9. The size of Wales makes it less likely to be commercially attractive to system suppliers and unable to influence any bespoke IT developments.

☐ Strongly agree (12%)

☐ Somewhat agree (46%)

☐ Disagree (36%)

☐ Strongly disagree (6%)



The questions below ask you to provide your level of agreement/ disagreement with different statements developed from the first round responses.

Figures in brackets show % category response in round 2.

10. The biggest concern about technology and AI in Pharmacy is its impact on jobs and replacement of workers.

☐ Strongly agree (12%)

☐ Somewhat agree (24%)

☐ Disagree (55%)

☐ Strongly disagree (9%)



The questions below ask you to provide your level of agreement/disagreement with different statements developed from the first round responses.

Figures in brackets show % category response in round 2.

11. Other professions are more willing to embrace digital tools.

- ☐ Strongly agree (3%)
- ☐ Somewhat agree (36%)
- ☐ Disagree (58%)
- ☐ Strongly disagree (3%)

12. A significant culture shift is required in Pharmacy to support technology rather than fear it.

- ☐ Strongly agree (21%)
- ☐ Somewhat agree (49%)
- ☐ Disagree (30%)
- ☐ Strongly disagree (0)

13. Pharmacists are too risk adverse to embrace new technology.

- ☐ Strongly agree (9%)
- ☐ Somewhat agree (33%)
- ☐ Disagree (55%)
- ☐ Strongly disagree (3%)

14. Pharmacy has poor vision for the business change that technology enables.

- ☐ Strongly agree (21%)
- ☐ Somewhat agree (33%)
- ☐ Disagree (39%)
- ☐ Strongly disagree (6%)

15. Community pharmacies and GP practices are more open to embracing new technology than hospital pharmacies.

- ☐ Strongly agree (12%)
- ☐ Somewhat agree (33%)
- ☐ Disagree (46%)
- ☐ Strongly disagree (9%)

16. The ageing demographic of some staff groups in Pharmacy is hampering the implementation of technological developments.

- ☐ Strongly agree (12%)
- ☐ Somewhat agree (33%)
- ☐ Disagree (52%)
- ☐ Strongly disagree (3%)

I would like to sincerely thank you for completing the final round of my Delphi study.

Once the data is analysed and the study is written up, you will receive an email containing a summary of the findings.

In the meantime, if you have any further questions or comments, please do not hesitate to contact me.

Kind regards,

Amy Jayham



Appendix o. Round three reminder emails, sent 2.1.24 and 9.1.24.

To:

Subject: Digital technology and AI in Pharmacy- Round Three reminder

Dear _____

Hope you had a lovely Christmas!

Just sending a little reminder about the email I sent about the third and FINAL round of the Delphi study.

It really is much shorter than the first two rounds and should only take a few minutes to complete.

[Embed survey link](#)

Thanks again for all your support with my study.

Best wishes

Amy

To:

Subject: Digital technology and AI in Pharmacy- Round Three reminder

Dear _____

Just sending a reminder about the third and final round of my Delphi research.

I would be very grateful if you could complete the below survey by the 12th January please.

[Embed survey link](#)

Thanks again for your support throughout the study.

Once the data is analysed and the study is written up, I will send out a summary of the findings.

Kind regards,

Amy

Appendix p. Information request to GPhC regarding sex split of UK and Wales registered pharmacists

From: Information Governance <infogov@pharmacyregulation.org>

Sent: 24 July 2024 10:49

To: Amy Jayham

Subject: FOI 2024-151 Response

Dear Amy

I am writing further to your request below. I can confirm the figures for pharmacists on our register as of today's date are as follows:

UK registrants

Gender	Registrants	%
Female	40,271	62.55%
Male	23,470	36.45%
Other	18	0.03%
Prefer not to say	205	0.32%
Unrecorded	419	0.65%
Total	64,383	100.00%

Wales registrants

Gender	Registrants	%
Female	1,711	61.90%
Male	1,040	37.63%
Other	1	0.04%
Prefer not to say	4	0.14%
Unrecorded	8	0.29%
Total	2,764	100.00%

Yours sincerely



Information Governance

General Pharmaceutical Council

Level 14, One Cabot Square | Canary Wharf | London | E14 4QJ

Email: infogov@pharmacyregulation.org

www.pharmacyregulation.org



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Appendix q. Response length for round one qualitative survey questions.

Participant	Number of words							
#	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Mean
1	46	25	39	8	3	10	11	20.29
4	69	11	49	67	39	17	25	39.57
5	13	11	13	31	39	26	21	22.00
8	10	12	3	7	13	1	1	6.71
9	16	6	26	18	20	22	10	16.86
10	103	30	45	42	15	36	42	44.71
11	13	22	7	18	29	34	16	19.86
12	19	14	36	37	29	30	54	31.29
13	30	8	8	21	20	18	14	17.00
16	33	7	24	57	68	32	12	33.29
17	6	8	15	13	6	8	10	9.43
18	24	26	17	60	73	89	87	53.71
19	26	12	53	13	14	37	38	27.57
21	14	3	7	15	2	21	11	10.43
22	15	5	4	17	65	43	42	27.29
23	127	100	48	34	36	20	32	56.71
24	66	19	36	60	29	20	34	37.71
26	74	10	76	49	27	9	26	38.71
27	14	5	16	85	16	53	27	30.86
28	8	7	31	19	23	8	7	14.71
29	22	18	14	36	23	16	9	19.71
31	5	1	2	9	12	48	26	14.71
32	6	7	22	22	65	17	0	19.86
36	5	2	14	21	39	37	63	25.86
37	8	10	20	51	12	29	12	20.29
39	158	84	36	52	61	22	6	59.86
40	18	9	11	33	7	18	21	16.71
41	10	2	5	3	3	10	5	5.43
42	30	5	30	16	46	16	9	21.71
46	49	74	130	17	31	25	120	63.71
49	7	1	4	8	4	2	7	4.71
51	30	2	0	16	2	13	5	9.71
53	9	5	2	12	10	13	7	8.29
54	11	7	0	29	46	13	12	16.86
56	6	2	0	22	16	17	18	11.57
58	26	22	0	0	0	0	0	6.86
61	54	26	6	130	66	39	71	56.00
62	20	1	38	30	27	28	11	22.14
Mean	31.58	16.29	23.34	31.00	27.26	23.61	24.26	25.33
SD	34.44	22.05	25.18	25.42	20.99	16.56	25.36	16.09
95% CI	10.95	7.01	8.00	8.08	6.67	5.27	8.06	5.12
CI from	20.63	9.28	15.34	22.92	20.59	18.34	16.20	20.22
CI to	42.53	23.30	31.35	39.08	33.94	28.87	32.33	30.45