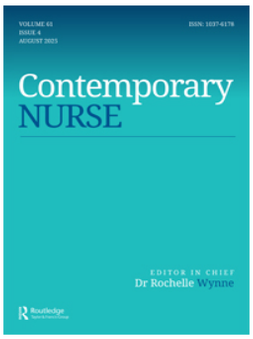

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Insights from the rapid implementation of digital technologies in nursing practice during COVID-19 – a survey

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The COVID-19-driven rapid adoption of digital technology required nurses to adapt their approach to patient care while simultaneously learning to integrate these technologies into their practice. The insights gained from this experience are essential for preparing the nursing workforce for future public health emergencies.

Aim: To explore nurses' adoption of digital technologies during the COVID-19 pandemic and their perceived impact on nursing practice in Australia, focusing on technology-supported workforce preparedness for future public health emergencies.

Design: A cross-sectional survey design.

Methods: Nurses who worked in clinical settings during the COVID-19 lockdown period were eligible to participate in this study. Participants ($N = 94$) completed a 41-item online survey of forced-choice responses, free-text open-ended questions, and a system usability rating. Data were analysed using descriptive statistics and content analysis.

Results: Ninety-four respondents representing various fields of nursing reported on 102 distinct digital technologies. These technologies were categorized into online communication ($n = 42$; 41.2%), patient monitoring/data sharing ($n = 20$; 19.6%), virtual appointments ($n = 16$; 15.7%), electronic medical records ($n = 15$; 14.7%), mobile applications ($n = 5$; 4.9%), information systems ($n = 3$; 2.9%), and e-prescribing ($n = 1$; 0.9%). System usability varied across different types of technology. Barriers to successful technology use included inadequate infrastructure, low staff and patient digital literacy, lack of organizational support and training, particularly when redeployed, and clinician attitudes.

Conclusion: Although study participants demonstrated high agility and adaptability when digital technologies were rapidly implemented, the data suggests a need for greater organizational support and proactive preparation for similar public health emergencies. One of the most critical lessons learned from the COVID-19 pandemic is that even though digital technologies may need to be rapidly deployed to effectively support healthcare delivery during public health emergencies, this deployment needs to be thoughtful. As climate change increases the frequency and severity of such crises, investing in the digital

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preparedness of the nursing workforce emerges as a strategic imperative and as an essential component to fostering workforce resilience and long-term sustainability.

Keywords: public health emergency preparedness; nursing; digital technologies; climate change

Impact

The study highlights the importance of leveraging lessons learned from the rapid implementation of digital technologies in healthcare during the COVID-19 pandemic to better prepare the nursing workforce for increasingly digitized healthcare environments and future health crises. This includes organizational responsibilities to thoughtfully design and implement digital health technologies and investment in healthcare workforce preparedness and resilience through strategic development of digital literacy, providing efficient infrastructure, and ensuring ongoing professional development in nursing digital practice during emergencies.

Plain language summary

The study provides valuable insights into digital technology adoption by Australian nurses in the early stages of COVID-19, contributing to global discussions on strategies needed to manage rapid deployment of digital health technologies during public health emergencies whilst simultaneously equipping the nursing workforce with professional digital skills for future public health emergencies through intentional preparedness.

Introduction

The 2024 State of Climate Report warns that the world is on course to miss the Paris Agreement's goal to limit global warming to 1.5 C and, therefore, face more climate-uncertain futures (Ripple et al., 2024) characterized by increased frequency, duration and intensity of natural disasters and spread of vector-borne diseases to new regions, amongst other threats (The Intergovernmental Panel on Climate Change (IPCC), 2022). For example, Japanese encephalitis, previously unseen in Victoria, Australia, was recently identified there, leading to fatalities (Liotta, 2022). Such emergencies disrupt healthcare systems, requiring innovative strategies to ensure the continuity of safe, quality care, especially for vulnerable populations, alongside emergency care demands and challenges already evident during the COVID-19 pandemic.

Public health emergencies also often necessitate the rapid adoption of digital technologies to provide healthcare in new ways. For example, during COVID-19, healthcare shifted to digital models of care to reduce in-person contact and limit transmission, requiring nurses to quickly learn and adapt to these technologies while providing care under highly stressful conditions (Abdolkhani et al., 2022; Dowding et al., 2023; Livesay et al., 2023; Morris et al., 2023). In Australia, just before COVID-19, modern electronic medical records were being increasingly implemented, dominating professional conversations about how best to educate the current and future workforce (Lokmic-Tomkins et al., 2021, 2022, 2023). However, the COVID-19 pandemic accelerated the integration of technologies such as telehealth, remote patient monitoring, virtual care, and e-prescribing, once considered part of a distant future, into immediate practice, shaping national digital health priorities (Department of Health and Aged Care AG, 2023). Within months of lockdowns, governance systems and structures were rapidly adjusted to support these new models of care, often without established evaluation or a sustainable implementation plan (Commonwealth of Australia, 2024). This left the Australian nursing workforce needing to quickly adapt their practice to new working conditions, including how they

engaged with patients (Livesay et al., 2023; Morris et al., 2023). Similar experiences were reported in the United Kingdom (Dowding et al., 2023).

Public health emergencies also put immense stress on healthcare systems and their workforce, often leading to burnout and psychological strain (Jarden et al., 2023). Despite the official end of the pandemic in May 2023, burnout and workforce shortages have fuelled a trend of 'quiet resignations,' exacerbating pressures on healthcare systems (Galanis et al., 2023; Jarden et al., 2023; World Health Organization, 2024). This exodus is partially driven by rapid shifts in the healthcare landscape and advancements in digital health technology (Beaulieu et al., 2023). This issue is further compounded by the lack of a national accreditation requirement for digital health and health informatics training in pre-registration nursing programs (Lokmic-Tomkins et al., 2022, 2024). Although several frameworks have been developed to improve nurses' digital competencies, their implementation and competency assessment remain optional, posing challenges to nursing education providers in Australia (Lokmic-Tomkins et al., 2024). The COVID-19 pandemic also widened the gap between the rapid growth in digital health technologies in clinical environments and the digital capabilities of Australia's nursing workforce, intensifying these challenges (Livesay et al., 2023; Morris et al., 2023).

One approach to addressing this crisis is to equip nurses with training that prepares them for public health emergencies that integrates the effective use of digital technologies. When nurses are trained to effectively integrate technology into their practice, they are more likely to feel confident, supported and less overwhelmed when delivering patient care, which helps reduce burnout and promotes well-being (Alshammari & Alenezi, 2023). To identify and develop strategies and mechanisms that improve nursing workforce preparedness in digitally-driven clinical environments for future public health emergencies, including the growing risks of global infectious diseases and natural disasters linked to climate change (The Intergovernmental Panel on Climate Change (IPCC), 2022), lessons from the COVID-19 pandemic can serve as a platform for better future preparedness. This study explored the adoption of digital technologies by Australian nurses during the COVID-19 pandemic and their perceived impact on nursing practice, to identify issues that need to be addressed if we are to strengthen the nursing workforce's preparedness for future public health emergencies.

Study aim

To explore the adoption of digital technologies by Australian nurses during the COVID-19 pandemic and their perceived impact on nursing practice, to identify key issues for strengthening workforce preparedness for future public health emergencies.

Objectives

Using an online, national cross-sectional survey, the study examined:

(a) the extent and nature of digital technology adoption among Australian nurses during the COVID-19 pandemic
(b) nurses' perceptions of how digital technologies impacted their clinical practice and professional roles.
(c) barriers and enablers to effective use of digital technologies in nursing during a public health crisis; and
(d) insights that inform strategies for improving digital preparedness in the nursing workforce for future emergencies.

Methods

Ethical consideration

Ethics was approved by Monash University HREC 35511 in accordance with The National Statement on Ethical Conduct in Human Research 2025.

Design and settings

A cross-sectional, national online survey. This was considered to be an appropriate and pragmatic method to capture a timely snapshot of trends and associations in nurses' adoption of digital technologies during a period when all Australian states had experienced some form of lockdown. This approach enabled broad, rapid, and cost-effective data collection across diverse geographic and demographic groups, ensuring national relevance and generalizability in a time-sensitive post-pandemic context (Evans & Mathur, 2005).

Recruitment

A call for participants and a link to the survey were disseminated across nursing professional networks in Australia using the snowballing technique (Johnson, 2005) and social media platforms LinkedIn, Facebook and Twitter (now X). The study advertisement contained a QR code and a direct link to participant information sheet, consent options and the study survey. Prior to proceeding to the survey questions, participants were required to indicate their consent to participate by checking a consent checkbox. Participants had to be registered nurses with the Australian Health Practitioner Regulation Agency (AHPRA), employed in healthcare services in Australia during the COVID-19 pandemic, and be aged over 18 years. This criterion was established due to the legal protection of the title 'nurse' in Australia (Nursing and Midwifery Board of Australia, 2024) and the necessity for participants to have used digital technologies for patient care during the pandemic.

Survey design

The survey was adapted from Dowding et al. (2023) developed in the United Kingdom by a team of nurses and academics and with the input of two patient and public involvement representatives, using the non-adoption, abandonment, scale-up, spread, sustainability (NASSS) framework as a guide (Greenhalgh et al., 2017). For its use in Australian settings, the survey was reviewed by two clinical nurses and two nursing academics for suitability to the Australian context. Survey adaptation was deemed necessary due to the Australian healthcare system being distinct from the United Kingdom's healthcare system with different frameworks regulating the nursing workforce scope of practice (Nursing and Midwifery Board of Australia, 2024). Specifically, we adapted the type of care organization where nurses worked as this would be different to UK and location of services to reflect classification of Australian territories and states as per Australian Statistical Geography Standard (Statistics ABo).

The 41-item survey (Supplementary File 1) included questions on demographics, digital technologies that had recently been adopted into the participants' services (up to three), and a final optional section on nurses' broader attitudes to healthcare technology. Nurses were also asked to rate up to three named digital technologies through a scoring matrix to inform how useful this technology was in supporting patient care during the pandemic. The survey comprised fixed-response and free-text questions, along with a rating of the technology's

usability reported by the respondent using the System Usability Scale (SUS) (Bangor et al., 2009; Digital.gov, 2024). Usability refers to the process of improving systems' ease of use and aligning them with the needs of the user. The SUS scale consists of 10 questions prompting respondents to indicate their agreement level from 'Strongly Agree' to 'Strongly Disagree' and is scored on a scale of 0 to 100, with higher scores denoting easier usability. Generally, a SUS score exceeding 70 indicates good usability (Bangor et al., 2009). None of the questions were compulsory to answer.

Data collection

The participants could complete the survey anonymously using Qualtrics XM, a web-based platform that is securely accessed through a two-factor authentication log-in. Once respondents had started the survey, they could revisit it for up to two weeks to complete it. Captcha was also activated to prevent AI-driven interference with survey data collection. No incentive was offered to respondents. The survey was active for six weeks during January 2022 and February 2022, a period that is approximately three months after the last lockdowns were ended in Australia (October 2021) (Reserve Bank of Australia, n.d).

Data analysis

Responses to fixed-responses questions were analysed using descriptive statistics. The scale for the SUS was converted into numerical values ranging from 1 for 'Strongly Disagree' to 5 for 'Strongly Agree'. SUS scores were calculated using the standardized method whereby SUS is determined by the formula (X + Y) x 2.5 (Brooke, 1996). Here X represents the sum of scores for all odd-numbered questions minus five and Y represents 25 minus the sum of scores for all even-numbered questions (Brooke, 1996). The results were mapped to demonstrate a usability score of 0 to 100 whereby 0–25 was the worst imaginable, 26–38 was considered as 'poor', 39–52 was 'satisfactory', 53- 72 good, 73–85 excellent, and above 85 was the best imaginable (Bangor et al., 2009; Bloom et al., 2021). GraphPad Prism 10 software was used to analyse all data. Prior to SUS calculation and based on technology reported in raw data, technologies were grouped into the following categories: e-prescribing, electronic medical records, information systems, mobile applications, online communication, patient monitoring and virtual appointments.

Where the answers to specific questions were missing, the data was coded as 999 to demarcate missing data for exclusion from further analysis (Lokmic-Tomkins et al., 2022). At the time of this study, the 2021/2022 Nursing and Midwifery Board Annual Summary reported that there were 356, 821 registered nurses and another 27, 885 dual-registered nurses and midwives in Australia (Nursing and Midwifery Board of Australia, 2023) totalling 364,706 potential participants. Using a sample size calculation with finite population correction where 95% confidence level and 5% margin error were assumed, the ideal sample size for the national survey size was 384 participants. Data provided in qualitative questions was content analysed (Lokmic-Tomkins et al., 2024) and summarized in tables. Data was reported as per Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) checklist for cross-sectional studies (von Elm et al., 2008).

Results

Participant characteristics

During the six-week period, 108 responders opened the survey link, but 94 proceeded to complete the survey either completely or partially. While the study was designed to achieve 95% power to detect a high effect size, the final achieved power was 42.7% due to a smaller-than-

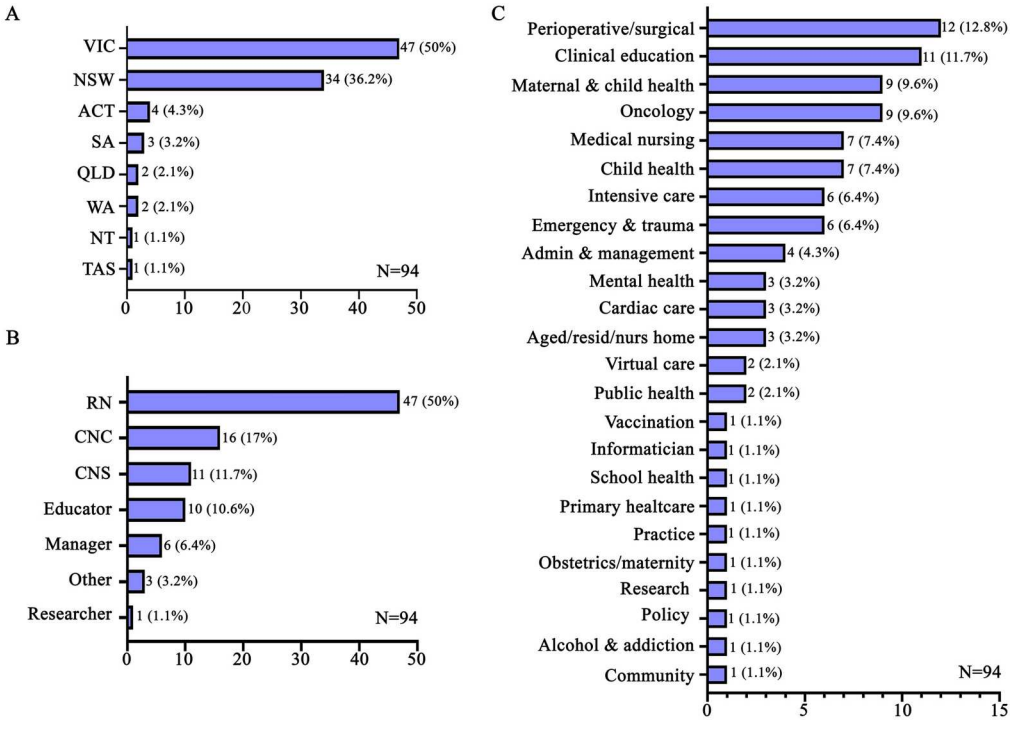

Figure 1. Participant demographics. A. Location of employer location; VIC = Victoria, NSW = New South Wales, ACT = Australian Capital Territory, SA = South Australia, QLD = Queensland. WA = Western Australia, NT = Northern Territory, TAS = Tasmania; B. Participant professional role; RN = Registered Nurse, CNC = Clinical Nurse Consultant, CNS + Clinical Nurse Specialist. C. Type of care delivery organization.

expected sample size ($N = 94$). From the 94 participants, 47 (50%) were from the state of Victoria, and 34 (36.2%) were from New South Wales (Figure 1(A)). In addition to registered nurses ($n = 47$, 50%), some participants identified as clinical nurse consultants ($n = 16$, 17%), clinical nurse specialists ($n = 11$, 11.7%), or clinical nurse educators ($n = 10$, 10.6%) (Figure 1(B)). The respondents represented many areas of nursing practice with most responders in perioperative/surgical nursing ($n = 12$, 12.8%), nursing education ($n = 11$, 11.7%), maternal and child health ($n = 9$, 9.6%), oncology care ($n = 9$, 9.6%), medical nursing ($n = 7$, 7.4%), neonatology/paediatric health ($n = 7$, 7.4%), intensive care unit ($n = 6$, 6.4%), emergency department and trauma ($n = 6$, 6.4%) (Figure 1(C)).

Implementation of digital technology in clinical practice during COVID-19

When asked if their access to technology has changed as the COVID-19 pandemic started, 91 participants completed this question with 74 (81.3%) participants responding that their access has changed, whereas 17 (18.7%) reported no change in access. The information on the introduced technologies was provided by 86 (91.5%) participants, of which 46 (53.5%) provided information on one type of technology, 23 (26.7%) provided information on two, and 17 (19.8%) provided information on three types of technologies. Collectively, participants described 102 technologies. These were grouped into seven categories: online communication ($n = 42$;

41.2%), patient monitoring ($n = 20$; 19.6%), virtual appointments ($n = 16$; 15.7%), electronic medical records ($n = 15$; 14.7%), information systems ($n = 3$; 2.9%), mobile applications ($n = 5$; 4.9%), and e-prescribing ($n = 1$; 0.98%).

The participants described this technology as possessing a variety of features ($n = 121$), such as supporting decision making ($n = 28$, 23.1%), real-time communication with patients ($n = 21$; 17.4%) and colleagues ($n = 22$;18.2%), remote patient monitoring ($n = 20$; 16.5%), sharing clinical information between organizations ($n = 15$, 12.4%), medication management (10; 8.3%), and allowing patients to enter their own data in their medical records ($n = 5$; 4.1%). These digital technologies were more likely to be standalone systems ($n = 32$; 50%), and just over half were introduced into the organization during the pandemic ($n = 34$; 53.1%), whereas 26 technologies (40.6%) were already in use. Integrated systems ($n = 26$, 40.6%) were also introduced.

Most systems were either developed by a healthcare specialist software company ($n = 17$; 31.5%) or provided by a vendor system ($n = 11$; 20.4%). Systems had several features, including to support decision-making ($n = 25$; 20.2%), support real-time consultation/communication with patients ($n = 21$; 16.9%), support real-time consultation/communication with colleagues ($n = 21$; 16.9%), and enable remote monitoring of patients ($n = 19$; 15.3%). The primary users of this technology were nurses ($n = 59$; 36.7%), followed by doctors ($n = 43$; 26.7%), patients ($n = 27$, 16.8%), and administrative staff ($n = 17$, 10.6%) while limited technologies were introduced to support carers ($n = 14$; 8.7%). Note that for these questions more than one answer was possible. A few systems enabled sharing of information between organizations ($n = 15$; 12.1%), managing medicines/prescriptions ($n = 10$; 8.1%), or allowing patients to enter data into their own records ($n = 5$; 4%).

Training needs

When asked if they have received sufficient training in using digital technologies at an individual level, 24 (44.4%) of 54 participants reported receiving sufficient training, 25 (46.3%) reporting as somewhat sufficient, and 5 (9.3%) reporting that they did not receive sufficient training. Similar results were seen when the participants ($n = 54$) were asked if they thought if other people received sufficient training, with 21 (38.9%) responding 'yes', whereas 25 (46.3%) responded as 'somewhat'. Interestingly, 42 (77.8%) participants reported that apart from training needs, other factors impacted how nurses used technology, including a lack of standardized competency in digital literacy amongst the nursing workforce (Table 1).

When asked if their organization had a dedicated team of nurses and/or other clinicians who are responsible for the implementation of digital technologies/solutions for nursing practice, 47 out of 94 (50%) nurses responded that their organization had a dedicated team while 18 (19.1%) did not have a dedicated team. Almost a third of participants ($n = 29$, 30.9%) were not aware if their organization had such a team. Most respondents ($n = 30$, 55.6%) thought that for most of the time there is a member of staff or support service they can ask for help when they have a problem with technology. Interestingly, the respondents differed little in their perceptions of whether this technology gives them more work ($n = 24$, 44.4%) or not (30, 55.6%). Whether the implemented digital technology was evaluated or not was also not clear, with 18 (33.3%) stating yes, 20 (37.0%) stating no, and 16 (29.6%) unaware of such evaluations. This technology addressed the needs of a diverse patient population most or some of the time ($n = 51$, 94.4%), and most participants were unaware of patients expressing concerns about the technology used in their care ($n = 36$, 66.7%). Although, a small proportion of participants ($n = 13$, 24.1%) perceived otherwise. Participants felt the technology enabled the continuity of patient care during the pandemic ($n = 33$, 61.1%) and thought they would continue to use the technology post-pandemic ($n = 47$, 87%). Additional participant considerations of digital technologies are highlighted in Table 2.

Table 1. Summary of factors impacting the use of digital technology in clinical settings.

Digital technology	Factors impacting use
Electronic medical records	Computer literacy
	Clinician attitudes ('unwillingness to learn')
	Insufficient training and support
	Connectivity issues – systems were 'slow'
	Software upgrades
	Availability of devices
	Portable computers could not be taken to COVID-19 patient rooms
Online communication	Poor interoperability
	Complex to navigate
	Inadequate knowledge of software use
	Insufficient training
	Time constraints
Patient monitoring	Patient digital literacy
	Staff digital literacy
	Staff attitudes
	Loss of data due to connectivity issues
	Interoperability issues with EMR
Virtual appointments	Computer literacy/digital literacy
	Challenges with internet connection for nurses and patients
	Outdated hardware or lack of hardware
	Privacy concerns due to lack of designated space to conduct virtual appointments
	Fear of change
Mobile applications	Patients did not have a phone – requirement for tablet
E-prescribing	Nothing reported
Information systems	Computer literacy
	Digital literacy

Digital technology usability

None of the systems had a SUS score above 70, which represents the industry standard for acceptable usability (Bloom et al., 2021; Brooke, 1996) (Figure 2). The highest mean usability score (68.4; SD 15.6) was seen for virtual appointment tools, whereas the lowest score (55.0; SD 20.8) was seen for electronic medical records. There was significant variation in SUS scores within technology type; for example, the lowest SUS score for electronic medical records was 12.5 (i.e. worst imaginable usability) through to 100 (i.e. the best usability).

From 40 participants who responded to the question on whether the pandemic highlighted problems with frequent use of technology 26 (65%) thought that it did. Table 2 highlights issues described with the use of described technologies. When participants were given options to describe their concerns on the use of digital health systems in Australian healthcare, 39 qualitative comments described concerns around loss of critical thinking and reasoning, training and support needs not being met particularly when deployed to another ward, lack of seamless communication between the systems and clunkiness of using technology when using personal protective equipment or maintaining infection prevention (Table 3).

Discussion

Our study contributes to earlier findings that most healthcare settings in Australia were unprepared for the rapid deployment of digital technologies during the COVID-19 public health

Table 2. Participants' perceptions of digital health adoption in healthcare settings.

Issues surrounding digital technology use*	*N* (%) 40 (100%)
Adequacy of resources (i.e. computers/laptops, hand held devices, Wi-Fi, stable internet connectivity) to suit the workflow and needs of nurses workflow	
Most of the time	16 (40%)
Some of the time	17 (42.5%)
Rarely	7 (17.5%)
General concerns related to the increased use of technology in the Australian healthcare system	
Yes	17 (42.5%)
No	23 (57.5%)
Use of shortcuts or workarounds such as skipping data entry or ignoring alerts and reminders	
Always	2 (5%)
Most of the time	5 (12.5%)
About half of the time	3 (7.5%)
Sometimes	22 (55%)
Never	8 (20%)
Suitability of most frequently used technologies to workplace	
Detractor	12 (30%)
Neutral	24 (60%)
Promoter	4 (10%)
Benefits of technology in patient care outweighing the drawbacks	
Strongly agree	13(32.5%)
Somewhat agree	18 (45%)
Neither agree nor disagree	7 (17.5%)
Somewhat disagree	1 (2.5%)
Strongly disagree	1 (2.5%)
Current attitude towards technologies	
Extremely positive	15 (37.5%)
Somewhat positive	17 (42.5%)
Neither positive nor negative	5 (12.5%)
Somewhat negative	3 (7.5%)
Extremely negative	0 (0.0%)

*This part of survey was optional, with n = 40 participants from initial 98 providing responses.

emergency (Abdolkhani et al., 2022; Livesay et al., 2023; Morris et al., 2023). While the workforce adapted positively, the COVID-19 pandemic also widened gaps between the rapid growth in digital health technologies in clinical environments and the digital capabilities of Australia's nursing workforce (Livesay et al., 2023; Morris et al., 2023), intensifying these challenges particularly when nurses were redeployed to wards with unfamiliar digital systems while also managing the pandemic-related strains.

The SUS scores, all below 70 in this study, suggests that users experienced significant usability challenges with the systems deployed. However, while digital technology usability is a key determinant of system adoption, user satisfaction and long-term engagement (Bangor et al., 2009; Bloom et al., 2021), this is a multidimensional issue. SUS is developed to provides a standardized measure of usability from a general perspective and it may not capture context-specific issues or system complexity, especially in specialized clinical settings (Melnick et al., 2021) and does not reveal the root cause of usability issues. Hence the issue could be with technology itself, whereby low usability may impede effective system utilization, reduce user trust and impact clinical decision-making and workflow efficiency (Carayon & Hoonakker, 2019). However, it can also be due to cultural acceptance at individual and organizational levels (Dowding et al.,

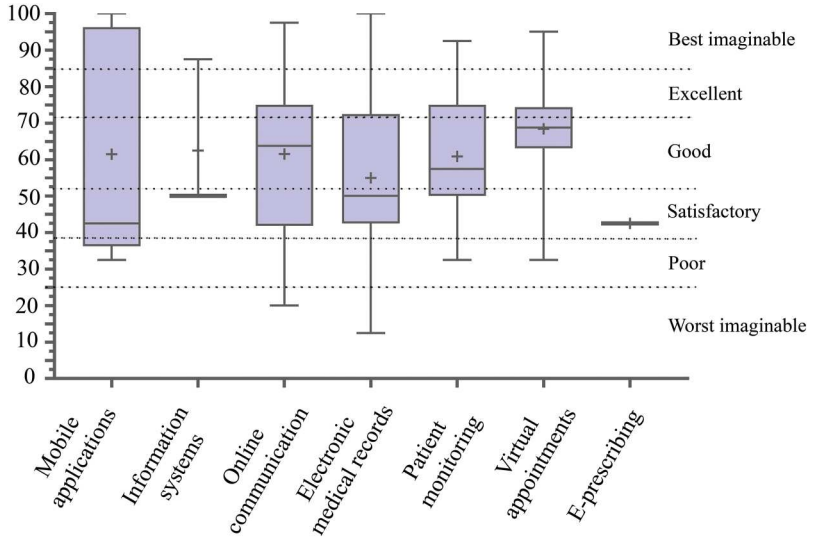

Figure 2. System usability score (SUS). The SUS is scored on a scale of 0–100, with higher scores denoting easier usability. A usability score of 0–25 is considered as worst imaginable, 26–38 is considered as 'poor', 39–52 is 'satisfactory', 53- 72 good, 72–85 is excellent while above 85 is the best imaginable.

2015). Examples of individual factors include experience of working with the system (professional digital literacy) (Dowding et al., 2009), while organizational factors revolve around investment in sufficient co-design and training needed for system implementation (Dowding et al., 2015; Melnick et al., 2021).

To address the digital preparedness, study participants suggested that minimum digital literacy competencies should be mandatory for all nurses at an organizational level. These suggestions align with findings by Morris et al. (2023) reporting that healthcare professionals, including nurses, preferred a state-wide or national approach to improving digital literacy over leaving it to individual healthcare services. To manage the strain of rapid implementation of digital health technologies during pandemic, they recommended that 'defining the minimum standard of digital literacy for health professionals in organizations and support them to achieve this and to 'provide high frequency training' in the 'minimum standard of digital literacy' to address high workforce turnover and shortages (Morris et al., 2023).

Generational differences also emerged, with older nurses perceived to struggle more with adapting to new technologies compared to younger nurses and receiving less support. Participants suggested that visible, tailored training in relevant digital literacy, designed to meet diverse needs, continuous support systems, including help desks, peer mentoring, or the presence of super-users could help nurses in navigating these challenges. While these strategies should be standard practice (Samadbeik et al., 2020), our findings indicate they are not consistently implemented. Other significant barriers to effectively utilizing digital technologies included inadequate training, poor digital infrastructure, device shortages, and managing challenges with multiple digital systems, including hybrid paper-digital models, which increased complexity and workloads. Addressing these problems will be integral to enabling the Australian nursing workforce being better prepared to respond to future public health emergencies in digitally driven environments.

These challenges are also reflected in variations in system usability with scores highlighting differing familiarity with technology, work environments, and support resources. Identifying

Table 3. Nurses' concerns on technology use.

Concerns surrounding digital technology use*	Examples of quotes
Critical thinking and reasoning	Reducing critical thinking, reducing quality if patient care and documentation, getting between nurse and patient, altering thought patterns and planning (for the worse). People try to interpret machines not clinically assess patients. Nurses leave machines to monitor and do not care.
Therapeutic engagement	Working in mental healthcare the relationship developed with a person is part of the therapeutic engagement and essential for recovery. Technology, in some instances, put a barrier in place for developing a therapeutic rapport. However, for some people it enables improved connection and openness.
Training needs not met	Just that the need to train and support is not being met before the implementation of these technologies in practice nor once up and running.
	We are not up to speed with services for education
User-driven design	Clinicians need to be involved with the technology that is needed at the planning stages and not at implementation. We need to be asked for feedback so this can lead to improvements. We need new and targeted approaches to the technologies used in secondary and primary care and we need universal records to improve evidence-based care across the sectors.
	The current technologies have not improved clinical communications or handovers. We have not improved comprehensive care with technologies
Preparedness for the future	A lot of money was spent on equipment so that we could use it during the pandemic, but not a lot of vision about continuing its use moving forward.
Failure of technology and infrastructure	Just that we don't seem to have reliable wifi and available training and support to be able to use it effectively.
	When the connection was poor it meant consultations with clients dropped out, very challenging when working with vulnerable populations in times of stress
	If the systems are not integrated it is very difficult to get information from, multiple systems in use and formats of the same program in different facilities, often connection issues or problems with systems
Technology meets the workflow needs	The keyboards on the mobile computers frequently failed and very difficult to use in full PPE. The screens too small to see through easily with the visors. No remote telemetry in most add settings despite the complexity of care delivery in the wards. Wifi constantly dropping out and all work lost. Integration of physiological obs via device rarely well integrated and manual entries required
	Missing data entry points e.g. ventilator settings could not be documented in easily accessible location on EMR when compared to ICU paper charts
	When we were in home isolation and expected to have access to the electronic medical record system – it was very hard and complicated to access.
	Constantly spending time online learning and updates, this limited time for clients. Constant data corrections.
	Electronic health record is clunky and awkward. Not user friendly at all.
	The cheap options are always the focus resulting in nurses having to try to make non-integrated systems work together.

(*Continued*)

Table 3. Continued.

Concerns surrounding digital technology use*	Examples of quotes
Mismatch between digital technology and community access	When connecting with a client for a telehealth appointment. If it doesn't work, we have been told it's a problem at the client's end, not our system. Highlighted community Internet access issues When the connection was poor it meant consultations with clients dropped out, very challenging when working with vulnerable populations in times of stress
Infection prevention	Infection control of shared devices

factors influencing these scores can guide targeted improvements, improving system adoption and satisfaction. Although best practice is to apply user-led implementation of streamlined, adaptable technologies that support nursing workflows and strengthen workforce resilience (Schoville & Faan, 2015), nurses reported not being consulted during the implementation of new technologies, which were often not user-intuitive, nor involved in usability testing, or workflow evaluations. In some cases, available communication technologies were rendered unusable due to poor internet connectivity and lack of interoperability. These issues are not new (Abdolkhani et al., 2022; Brown et al., 2020) and it is concerning that they persist. Evidence clearly indicates that the careful management of digital technology implementation helps avoid unintended consequences such as increased workload, workflow inefficiencies, and cognitive strain, factors that contribute to staff burnout and, ultimately, affect workforce retention (Dykes & Chu, 2021; Holton et al., 2023; Livesay et al., 2023). Addressing these challenges in preparation for future public health emergencies requires ongoing organizational readiness and a thoughtful, structured approach to emergency change management, to mitigate the risks associated with rapid deployment of digital technologies without adequate planning (Alotaibi et al., 2025).

To address these issues, including low SUS scores, it is fundamental to involve nurses in the design, testing, and evaluation of digital technologies to ensure they meet user needs (Dykes & Chu, 2021). Additionally, regular feedback loops and continuous improvement post-deployment should be prioritized to optimize technology integration in healthcare settings, particularly under challenging conditions like those experienced during COVID-19. Challenges identified in this study and others examining similar issues (Dowding et al., 2023; Livesay et al., 2023; Morris et al., 2023) highlight the need for stronger organizational support to better equip nurses in their workplaces. Such support needs to be delivered in the context of preparedness for future public health emergencies starting with addressing ongoing gaps in digital literacy and computer competencies. Yet, despite increasing digital integration in healthcare, essential informatics skills for safe nursing practice remain suboptimal due to inadequate training at the pre-registration training level (Dowding et al., 2023; Livesay et al., 2023; Lokmic-Tomkins et al., 2024; Morris et al., 2023; Schwartz et al., 2020). We would further argue that without making high-quality informatics education and training mandatory at the organizational level, particularly given the lack of mandatory training in pre-registration nursing programs, strengthening nursing readiness for similar crises in digitally-driven environments will remain problematic. Investing in organizational efforts to support nurses in adopting digital technologies, especially as public health emergencies are expected to increase with climate change's impact on planetary health, is essential.

One approach is integrating health informatics and digital health competencies, as outlined by the Technology Informatics Guiding Education Reform (TIGER) framework (Hübner et al., 2018) and the International Council of Nurses Disaster Nursing Competencies (International Council of Nurses, 2019), envisioning every nurse as both an 'e-nurse' and a disaster nurse. This aligns with the World Health Organization's (WHO) operational framework for climate-resilient healthcare systems, aimed at enhancing health systems' capacity to protect and improve population health amid climate instability (World Health Organization, 2023). The WHO defines a climate resilient health system as: 'one that is capable to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, so as to bring sustained improvements in population health, despite an unstable climate' (World Health Organization, 2023, p. 4). One of the framework's building blocks, is the healthcare workforce, emphasizing 'strengthening of technical and professional capacity of health personnel, the organizational capacity of health systems, and their institutional capacity to work with others.' (World Health Organization, 2023, p. 16). To strengthen the digital capacity of the nursing workforce for future public health emergencies and by deriving lessons from this and other global studies, the next step is to develop an international framework for a globally resilient, digitally enabled nursing workforce. This proposed framework would differ from existing disaster nursing competencies, as its focus is on required digital literacy to manage emerging digital technologies, including generative AI.

Limitations

The power achieved with an actual sample size of 94 participants is 42.7%. This means the study had less than half the desired statistical power to detect the effect. The participants also self-selected to complete the survey so volunteer bias may exist. Recall bias may also play a role as the data collection occurred once the COVID-19 pandemic lockdowns eased off. However, as most respondents were from Victoria, a state under the harshest and longest lockdown restrictions for 262 days (Vally & Bennett, 2021), and New South Wales, in lockdown for approximately 107 days (BBC, 2021), the experiences reported are likely to reflect the raw reality of rapid implementation of digital technologies in early public health restrictions in response to COVID-19.

Conclusion

The rapid digitalization of healthcare due to COVID-19 has reshaped nursing practice, offering benefits in efficiency, accessibility, and disease transmission control. However, given the growing impact of climate change on healthcare systems, which extends beyond natural disasters to create ongoing pressures, challenges identified in this study must be addressed to better prepare the nursing workforce for future public health emergencies. Focus should be placed on developing digital skills and supporting nurses' well-being to ensure they can confidently use emerging technologies under the pressures of public health emergencies. This can be achieved by creating a digital preparedness framework that encompasses digital skills training for patients, carers and nurses, responsible technology implementation, and prioritization of both patient and nurse well-being. Investing in digital health integration, training, and support is essential to ensure successful digital transformation, reduce workforce burnout, and enable nurses to respond effectively and resiliently to future public health crises.

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Supplemental data

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