

Managing the Digital Disruption Associated with COVID-19-Driven Rapid Digital Transformation in Brisbane, Australia

Amalie Dyda¹ Magid Fahim^{2,3} Jon Fraser⁴ Marianne Kirrane^{4,5} Ides Wong⁶ Keith McNeil⁶
Maree Ruge^{3,7} Colleen L. Lau^{1,8} Clair Sullivan^{3,4}

¹ School of Public Health, University of Queensland, Queensland, Australia

² Metro South and Integrated Nephrology and Transplant Services, Princess Alexandra Hospital, Queensland, Australia

³ Centre for Health Services Research, University of Queensland, Queensland, Australia

⁴ Digital Metro North, Metro North Hospital and Health Service, Brisbane, Australia

⁵ Faculty of Medicine, University of Queensland, Queensland, Australia

⁶ Queensland Health, Brisbane, Queensland, Australia

⁷ Digital Metro North, Metro North Hospital and Health Service, Queensland, Australia

⁸ Research School of Population Health, ANU College of Health and Medicine, Australian National University, Australian Capital Territory, Australia

Address for correspondence Amalie Dyda, PhD, The School of Public Health, University of Queensland, 288 Herston Rd, Herston, QLD 4006, Australia (e-mail: a.dyda@uq.edu.au).

Appl Clin Inform 2021;12:1135–1143.

Abstract

Background The COVID-19 pandemic has forced rapid digital transformation of many health systems. These innovations are now entering the literature, but there is little focus on the resulting disruption.

Objective We describe the implementation of digital innovations during the COVID-19 response of Australia's largest health service, Metro North (in Brisbane, Queensland), the challenges of the subsequent digital disruption, how these were managed, and lessons learned.

Methods Prior to the COVID-19 pandemic, the Australian state of Queensland created the Queensland Digital Clinical Charter, which provides guidance for the development of digital health programs. The guidelines utilize three horizons: digitizing workflows, leveraging digital data to transform clinical care, and reimagining new and innovative models of care. The technical response to COVID-19 in Metro North is described across these horizons. The rapid digital response caused significant disruption to health care delivery; management of the disruption and the outcomes are detailed. This is a participatory action research project, with members of the research team assisting with leading the implementation project informing the case report content.

Results Several digital innovations were introduced across Metro North during the COVID-19 response. This resulted in significant disruption creating digital hypervigilance, digital deceleration, data discordance, and postdigital “depression.” Successful

Keywords

- COVID-19
- clinical information systems
- digital disruption
- emergency and disaster care

received
July 6, 2021
accepted after revision
October 15, 2021

© 2021. Thieme. All rights reserved.
Georg Thieme Verlag KG,
Rüdigerstraße 14,
70469 Stuttgart, Germany

DOI <https://doi.org/10.1055/s-0041-1740190>.
ISSN 1869-0327.

management of the digital disruption minimized the negative effects of rapid digital transformation, and contributed to the effective management of the pandemic in Queensland.

Conclusion The rapid digital transformation in Metro North during COVID-19 was successful in several aspects; however, ongoing challenges remain. These include the need to improve data sharing and increase interoperability. Importantly, the innovations need to be evaluated to ensure that Metro North can capitalize on these changes and incorporate them into long-term routine practice. Moving forward, it will be essential to manage not only the pandemic, but increasingly, the resultant digital disruption.

Background and Significance

Digital disruption is defined as “advancements in digital technologies that occur at a pace and magnitude that disrupt established ways of creating value within or across markets, social interactions, and, more generally, our understanding and thinking.”¹ Digital disruption occurs when emerging digital technologies impact, or disrupt, existing technologies, services, and procedures. When digital transformation occurs rapidly, this can exacerbate the challenges.² Digital disruption in health care is well characterized,^{2–4} with

several key challenges often encountered (►Table 1). However, little is known about the significant digital disruption created by the accelerated and deep digital response to the COVID-19 pandemic.

The digital disruption which resulted from large-scale digital innovations that occurred worldwide during the pandemic is beginning to be described in the literature. Several interventions were introduced across China including online medical consultations, online appointment registrations, and hospital self-service systems.⁵ More broadly, the global digital innovations span numerous response

Table 1 Definitions and examples of challenges faced during the digital disruption

Disruption challenge	Definition	Case study finding during COVID-induced digital disruption
Digital hypervigilance	“The tendency during digital transformation to overreact to potential issues or to erroneously attribute adverse events to the new technology due to heightened awareness or sensitivity induced by rapid, large-scale change” ²	This was measured by concerns raised by staff members. Issues regarding data security and privacy were raised during the COVID technological innovation. The use of Microsoft Teams for telehealth required a significant shift in the security requirements previously applied to this service which caused some concerns
Digital deceleration	The “transient, reduced operational efficiency in the postdigital transformation period” ²	Reductions in hospital operational efficiencies were encountered due to the use of Microsoft Teams. Several the innovations implemented required the use of this software. Staff were initially slow when using this technology and encountered several issues, such as individuals understanding and maneuvering the mute function. However, over time staff became more adept with the new technologies. Publicly reported hospital and telehealth outcome data also showed that efficiency in terms of outcomes was not impacted
Data discordance	Data from different sources do not match or data variables have the same name but measure different factors ²	While case definitions for COVID-19 were standardized across Australia, reports from staff involved in leading the implementation suggested there was discordance between the level of detail provided and the requirements of the digital system
Postdigital “depression”	“The singularly focused efforts of the organization in adapting to the transformation can occur at the expense of enthusiasm and resources for other important change activities” ²	Staff involved in leading the innovation provided information regarding some of the deficiencies of the new technologies, which were a result of the rapid implementation. It was postulated that this may lead to health care worker dissatisfaction with systems over time

activities including surveillance, testing, contact tracing, and clinical management with specific examples including artificial intelligence, analysis of big data, telehealth services, and mobile health applications.^{6–9}

Recent additions to the literature show COVID-19 have increased the need for rapid innovation to support clinical and public health responders.^{10,11} The drivers for this rapid innovation include the need to deliver care virtually and the need for real-time information to guide response. A key innovation has been rapid digital transformation of health care and management of electronic data. During this process, many health systems have reported issues with service delivery, staff anxiety and burnout (particularly in relation to increased electronic medical record use), concerns about privacy and data security, and coordination of data collection and communication.^{5,6,10–15} These issues can be described as “symptoms” of digital disruption. The majority of these studies focused on only one or two of these issues, with many identifying challenges during a specific innovation. Few have focused on the effects created by rapid large-scale technological change. Better understanding of the disruption associated with the pandemic is critical to ensure future digital implementations take these lessons into consideration.

Australia is considered a global exemplar in the management of the COVID-19 pandemic.¹⁶ Many digital health innovations were introduced during Australia’s successful response to the pandemic.^{17,18} The first COVID-19 case in Australia was identified in January 2020. Cases peaked in July 2020 with 10,224 notifications, after which public health measures were successful in minimizing the spread.¹⁹ The Australian state of Queensland had one of the most successful responses in Australia, with a total of 1,655 cases and 7 deaths reported by June 20, 2021.²⁰

In Metro North, the largest health service in Queensland, Australia, the digital health response to the pandemic was particularly vigorous and a suite of digital innovations in response to the pandemic were rapidly implemented. Prior to the pandemic, the jurisdiction had already commenced on a digital transformation journey, with a single electronic medical record across 5 million people and a digital clinical charter guiding and aligning thinking. More broadly, government level investments in health information technology in Australia were already increasing prior to the pandemic. In 2016, the Australian Digital Health agency was funded and formed using the declaration of the Public Governance, Performance and Accountability (Establishing the Australian Digital Health Agency) Rule.²¹ This is comparable to increases in funding in countries like the United States where federal programs such as the HITECH Act portions of the American Recovery and Reinvestment Act 2009,²² have been implemented to increase investments in digital health.

The pandemic truly accelerated the digital transformation in Metro North. As this large health service rapidly shifted to digital workflows and innovative models of care, significant digital disruption occurred. We describe below, not only the innovations developed during the COVID-19 response but the challenges of the digital disruptions and how these were navigated.

Objective

In this case report we aim to describe the digital disruption evoked by a rapid technical and data-driven response to COVID-19 and lessons learned.

Methods

Setting and Participants

Queensland has a population of approximately 5,220,561 people.²³ Universal primary health care is provided Australia-wide by the federal government with public hospital care funded by individual states and territories.²⁴ Metro North is the largest health service in Australia, serving over 1 million people with an annual budget in excess of AUD3B.²⁵ The service encompasses six hospitals, two of which provide specialist services, three secondary hospitals, and one regional hospital. Metro North also services Brisbane’s international airport and seaport.^{25,26}

Approach

Metro North implemented several technical and data innovations to respond to the COVID-19 pandemic. The rapid implementation of digital workflows and innovative models of care was difficult and risk-laden, especially during a very challenging and unpredictable time. Fortunately, Queensland had recently undergone a wide consultation and consensus-seeking activity to create a set of principles to guide digital transformation: the Queensland Digital Clinical Charter.²⁷

This consensus document provides guidance for the development and implementation of digital health programs to ensure that clinicians are a key part of the decision-making process. The guidelines are described across three horizons: digitizing workflows, leveraging digital data to transform clinical care, and reimagining new and innovative models of care (→Fig. 1).²⁸ Each aspect of the digital response to COVID-19 in the Metro North is described across these horizons.

This is a participatory action research project, with members of the research team assisting with leading the implementation project informing the case report content.

Results

Digital Initiatives

Details on digital initiatives implemented in Metro North in response to COVID-19 are described in →Table 2.

Digital Disruptions and Challenges during COVID-19 Digital Response

Due to the deep and accelerated nature of the digital disruption during the pandemic in Metro North, several difficulties were encountered (→Table 1).

Digital hypervigilance regarding data security was an issue raised, which has previously been identified by several pandemic digital innovations.^{5,10} Security is important in the implementation of telehealth services³⁵; consequently, the existing platform provided this to a high level. However, the pandemic shifted the balance between scalability and access,

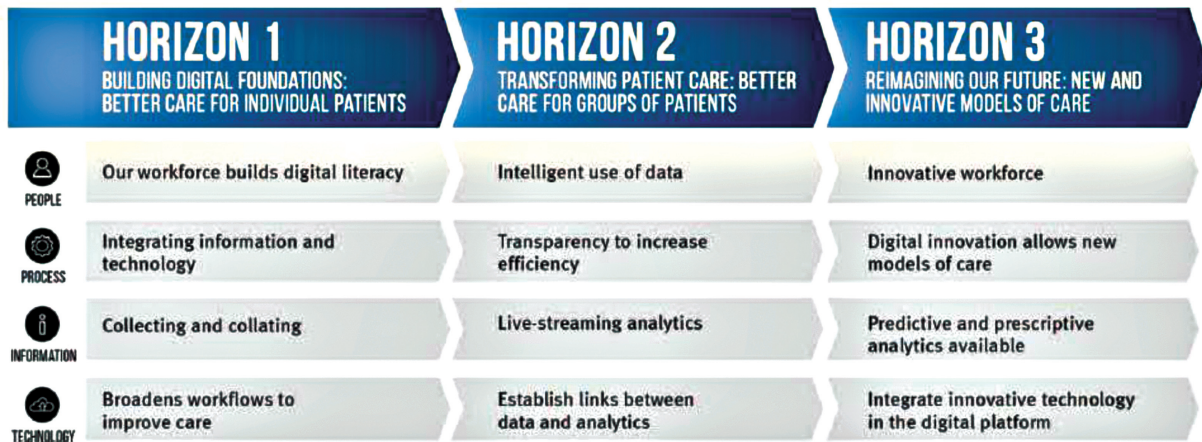


Fig. 1 Digital clinical strategic framework to assist with articulation of clinical requirements for digital transformation.^{26,27}

requiring the use of an alternate platform for telehealth. Specifically in Metro North, the use of Microsoft Teams required a significant shift in access requirements. Due to consumer and clinician demand, this change will likely be difficult to reverse, highlighting the need for updated ethical guidelines regarding the use of telehealth in both hospitals and primary care.³⁶

Digital deceleration was evident in the initial stages of the digital disruption. The introduction of new technology often involves a steep learning curve and results in an initial decrease in productivity.² Several initiatives required the use of Microsoft Teams with staff encountering numerous issues with this technology; however, over time they became more adept. After initial issues, the new models of care ameliorated performance and digital disruptions did not negatively impact efficiency and productivity. Despite pressures of the pandemic on emergency department performance and the rapid intro-

duction of new technologies, in 2019 to 2020 the percentage of category 1 patients (the most urgent triage category) seen within 2 minutes increased from 99.4 to 99.8% in Metro North.²⁶ The literature shows mixed results of health system performance in response to digital transformation.^{37,38} This case study demonstrates that it is possible to rapidly introduce digital innovation and transformation without compromising service delivery, even during a health crisis.

Data discordance has also been identified as an issue during digital transformation,² and specifically within the COVID-19 context.¹² In general, there was a lack of agreed data standards which limited the ability to rapidly exchange and utilize data from different areas. In addition, the national standardized case definition for suspected COVID-19 was not congruent with digital classification.³⁹

Postdigital “depression” can result in staff experiencing exhaustion after participating in a rapid digital transformation of their clinical workflows.² For example, Digital Corona Virus Application (DCOVA) provided many benefits for Metro North throughout the pandemic. However, as with any innovation, the application is not without problems. After the initial disruption, staff can become fatigued regarding further change.² It will be important going forward to continue to improve the new digital workflows, while helping staff to accept the changes, and emphasize that no system will never be perfect.⁴⁰

Characteristics of the Response

Several key strengths contributed to this accelerated digital transformation (→ **Table 3**).

Lessons Learnt

Several important lessons were learnt throughout the implementation which may provide guidance for future rapid transformations. Importantly, Australia had few cases of COVID-19 compared with many countries, hence it is likely that the difficulties encountered would be amplified in hospitals with heavier caseloads.

Finding new ways to work was important. For example, the development of new technologies was time pressured

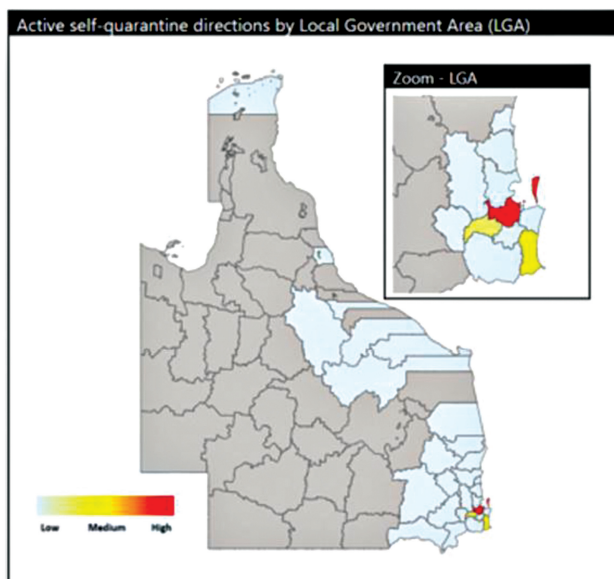


Fig. 2 Real-time heat maps of COVID-19 public health order using Digital Corona Virus Application (DCOVA) data (source Metro North, 2021).¹⁸

Table 2 Digital innovation implemented in Metro North during the COVID-19 response

Horizon	Innovation	Description
Horizon 1: Building digital foundations	Replacing paper-based medical records with the Cerner Integrated Electronic Medical Record (ieMR) ²⁹ for testing	To relieve the data entry burden, a workflow to rapidly record COVID-19 testing was set up in Cerner ieMR to ensure consumer centered care could be provided digitally across the health service
	Texting of COVID-19 test results directly from laboratory to consumers	An application was developed to text results to consumers directly from both public and private pathology laboratories. This replaced the time-consuming task of requiring clinicians to call patients with results
	Management of staff sick leave in relation to COVID-19 absences	An application was developed which allowed staff to digitally notify managers of sick leave to allow rapid replacement of staff with special skills (e.g., ventilator competent intensive care nurses)
	Digital Corona Virus Application (DCOVA)	A secure Web-based application, DCOVA, utilizes a cloud-based data warehouse that captures and integrates information about people required to quarantine. The application links numerous data sources including surveillance data, quarantine information, and laboratory testing data, and stores information in a secure multiagency database. The application is used by several agencies in Queensland, including Queensland Health, Queensland Police Service, and the Department of Housing and Public Works ¹⁸
Horizon 2: Transforming patient care	Integrate private and public pathology results into data lake	Pathology testing for COVID-19 occurs at multiple private and public laboratories. To streamline data collection and reporting, all COVID-19 test results from all private and public testing facilities for Metro North consumers were pooled into a single data lake
	Data extraction to improve decision making for clinical and public health response	DCOVA provided improved data integrity which enabled validated data outputs based on information from numerous sources. Additionally, the application provided analyses to identify vulnerable populations and several predictive analytical models and data visualizations. ¹⁸ An example of these visualizations is provided below in ►Fig. 2
Horizon 3: Reimagining the future	Three-dimensional (3D) printing of face shields	The global demand for personal protective equipment (PPE) meant that the need outweighed supplies during initial phase of the pandemic. With limits on the availability of crucial personal protective equipment for frontline hospital staff, ³⁰ Metro North developed and evaluated the use of 3D printed face shields. The results showed that the printed face shields provided physical protection against droplets at levels similar to commercial products. Following the successful evaluation, a framework for evaluating nontraditional PPE was developed ³¹
	Virtual visiting for hospital inpatients	While visiting was banned in hospitals, tablets and Microsoft Teams were used to create workflows for families to stay in touch with their hospitalized members
	Virtual emergency department (ED)	EDs were under considerable pressure during the initial stages of the Australian pandemic. ³² Using tablets and Microsoft Teams allowed general practitioners and residential aged care facilities direct contact with an emergency physician to manage emergency cases remotely
	Virtual Staff Forums	The 19,000 Metro North staff ³³ were anxious and apprehensive about the impact of COVID-19 on their own, and their families' health. Traditional face-to-face staff forums were converted to large online events using Microsoft Events, enabling thousands of staff members to directly ask questions of the executive team
	Virtual ward	This model of care allowed COVID-19 patients to be managed effectively in their own homes. This was achieved by providing patients with tablets, Microsoft Teams, and remote vital signs collection ³⁴
	Virtual care	Queensland Health has a previously developed platform for telehealth which is highly secure to ensure patient privacy. However, this could not be scaled up to meet demand during the pandemic, and Microsoft Teams was rapidly implemented to fill this need

Table 3 Characteristics of the Metro North digital response

Strength	Description
Culture	The urgency of the response increased key stakeholders' appetite for risk. Agile thinking was used and supported as traditional information and communication technology (ICT) project approaches were not conducive to problem solving. For example, a pair programming approach was used to develop new technology requiring clinical and software developers to work together in real time, replacing the traditional develop/review cycles ⁴¹
Leadership and vision	There was significant buy-in for new technologies from leadership and an established digital strategy had already been formulated, agreed, and socialized prior to the commencement of the pandemic ²⁸ A clear driver for technology adoption was constantly present with the threat of the pandemic forcing the introduction of new digital initiatives
Governance	Governance became decentralized and decision making was devolved to the local teams which allowed rapid decision making
Information was used to drive strategic and policy decision	Data collected via the digital applications was used to inform the containment strategy and opening/closing of interstate borders. This immediately demonstrated the value of the new digital applications and drove deep adoption by clinical staff
Funding	Emergency COVID-19 funding was made available and used to support the development of many of these initiatives ⁴²
Leveraging existing capacity	There was an established business as usual applications development team
Preexisting technologically advanced system	The digital systems already in place in Metro North were advanced prior to the pandemic, including a new integrated electronic medical record (ieMR), a digital record of individuals' medical history across providers ²⁹ and existing robust infectious disease surveillance systems ⁴³
Data and digital literate workforce	Both the clinical and public health workforce in Metro North had high baseline levels of digital and data literacy given the number of digital innovations implemented prior to the pandemic ²⁶

due to policy directions, requiring fast-paced development.¹⁸ Traditional methods for health technology development rely on an iterative process between developers and users which takes time. To improve development time, pair programming was used to develop DCOVA. This required users and clinical informaticians to work together with developers in real time.^{18,31} The use of this innovative process enabled the successful development of tools in a rapid time frame.

Data standards and interoperability need to be addressed at a broader level. This is important for public health response and reporting, as well as clinical care. While the digital initiatives in this instance were successful, they were localized to one hospital and health service. In a devolved environment, the only way to ensure statewide and nationwide real-time data are with interoperable systems and unified data standards. Currently in Australia, jurisdictions use different operating systems.⁴⁴ The need for greater interoperability has been identified previously in several countries.^{45,46} Following Australia's initial COVID-19 response, the First Interim Report from The Senate Select Committee on COVID-19 recommended the development of an Australian Centre for Disease Control to improve coordination between jurisdictions which may assist to address some of these issues.⁴⁷

Improving data standards and interoperability is also important for primary health and clinical care. Individuals have numerous interactions with the health system, which

provides opportunities to combine information from multiple health care providers. This provides the clinician or health care provider greater detail about an individual which results in better clinical decisions and patient outcomes.⁴⁸

Data sharing with people outside of the hospital health system could be improved. The initiatives described here focus on services regulated under Metro North. Increasing the availability of key health information, particularly during outbreaks or pandemics, is important for clinicians who do not work in hospitals, other primary care providers, and, in some instances, the general public. The implementation of data sharing will need to be carefully considered to ensure the protection of individual patient data privacy.⁴⁹

A technical debt has accrued throughout the transformation given the rapid and pressurized manner in which innovations were developed and implemented. A technical debt is incurred when digital innovations are expedited and result in some issues of longer-term maintainability being omitted.⁵⁰ This often requires ongoing, postimplementation, improvements. One proposed strategy for managing technical debt is the "Strategic Technical Debt Management Model" which involves: situation analysis, strategy formulation, strategy implementation, and evaluation and control.⁵⁰ This type of model will be adopted to address the operational and technical debt accrued in Metro North.

Considering these lessons learned will likely be useful for other health systems undergoing significant technological shifts, with specific attention paid to thinking in innovative

ways, interoperability, and working with staff to manage expectations regarding technical debt.

Discussion

To ensure that the digital innovations continue to be utilized long term, each challenge needs to be appropriately addressed. Consolidation of each aspect of the transformation will be important. Staff leading the transformation will need to evaluate each innovation from different viewpoints including cultural and security perspectives, usability, and usefulness, considering the different types of users. The evaluations will consider which aspects of the transformation are needed long term, and which were required short term for the initial pandemic response. Previous research has identified that to enhance ongoing acceptance and use of new digital technologies, it is important they are integrated in ways that align with current organizational culture.⁵¹

These findings highlight the current gaps in knowledge in this area, specifically regarding digital disruption. Future work in this area could focus on not only evaluating each aspect of the transformation, but the impact as a whole. This whole of system approach would also assist in making these findings more generalizable. The impacts of the innovations on patient outcomes and experiences will also be important to evaluate to further understand the utility of the innovations and identify areas for improvement.

Limitations

To date, restricted resources have not allowed a formal evaluation of the impact of digital innovations in Metro North on patients and their families. Future work should include a formal review of each of the different departments within Metro North, as well as evaluations of the impacts on patients and their families.

Conclusion

The rapid digital transformation in Metro North during the initial phases of the COVID-19 pandemic was successful in several aspects, including maintaining high levels of clinical care, providing virtual care when face-to-face care was unavailable, and assisting with the continuing pandemic response efforts. Ongoing challenges were identified which will require continuous attention to overcome. Most importantly, the innovations which were implemented need to be evaluated to ensure that Metro North can capitalize on these changes and incorporate them into long-term routine practice. Moving forward it will be essential to manage, not only the pandemic, but also the digital disruption which has occurred.

Clinical Relevance Statement

This article provides information regarding key lessons learned during the implementation of several digital technologies in response to the COVID-19 pandemic and describes the resulting digital disruption. This may provide

leaders in digital health with valuable insight to successfully implement future COVID-19 digital interventions.

Multiple Choice Questions

- When implementing large scale digital health innovations, which of the following is important in regard to statewide and nationwide data reporting?
 - Having technologically advanced information technology systems.
 - Data standards and interoperability.
 - Email communication between stakeholders.
 - Staff trained in Microsoft Teams.

Correct Answer: Option b is the correct answer. The use of digital technologies for reporting can negate the need for email and other types of data and information sharing processes. However, this requires that cooperating jurisdictions are using the same data standards to allow for appropriate comparisons, as well as the use of information technology systems that are interoperable, or able to exchange information. The need for improved interoperability in digital health has been identified globally.

- When implementing large scale digital innovations during a pandemic, which of the following is correct?
 - Focusing on the technology and how it operates is most important.
 - The introduction of technology during a pandemic always improves the response.
 - Large scale change is likely to be well accepted by staff with no negative impacts.
 - Managing the resulting digital disruption is equally as important as the initial implementation.

Correct Answer: Option d is the correct answer. When large scale digital innovation is implemented, there is resulting disruption, which presents itself in many ways including digital deceleration and postdigital “depression.” To ensure that innovations are correctly implemented and incorporated in the long term, managing the digital disruption is important with research showing new digital technologies are integrated in ways that align with organizational culture.

Protection of Human and Animal Subjects

No human subjects were directly involved in this project.

Conflict of Interest

None declared.

Acknowledgment

Assoc. Prof. Sullivan would like to acknowledge the support of the Digital Health Cooperative Research Centre.

References

- Riemer K, Gal U, Hamann J. Digital disruption intermediaries: finding new digital opportunities by disrupting established business models. 2015 Accessed November 8, 2021 at: <https://ses.library.usyd.edu.au/handle/2123/12761>

- 2 Sullivan C, Staib A. Digital disruption 'syndromes' in a hospital: important considerations for the quality and safety of patient care during rapid digital transformation. *Aust Health Rev* 2018;42(03):294–298
- 3 Eden R, Burton-Jones A, Scott I, Staib A, Sullivan C. Effects of eHealth on hospital practice: synthesis of the current literature. *Aust Health Rev* 2018;42(05):568–578
- 4 Shaw B, Chisholm O. Creeping through the backdoor: disruption in medicine and health. *Front Pharmacol* 2020;11:818
- 5 Ye J. Health information system's responses to COVID-19 pandemic in China: a national cross-sectional study. *Appl Clin Inform* 2021;12(02):399–406
- 6 Knighton AJ, Ranade-Kharkar P, Brunisholz KD, et al. Rapid implementation of a complex, multimodal technology response to COVID-19 at an integrated community-based health care system. *Appl Clin Inform* 2020;11(05):825–838
- 7 Whitelaw S, Mamas MA, Topol E, Van Spall HGC. Applications of digital technology in COVID-19 pandemic planning and response. *Lancet Digit Health* 2020;2(08):e435–e440
- 8 Ye J. The role of health technology and informatics in a global public health emergency: practices and implications from the COVID-19 pandemic. *JMIR Med Inform* 2020;8(07):e19866
- 9 Hron JD, Parsons CR, Williams LA, Harper MB, Bourgeois FC. Rapid implementation of an inpatient telehealth program during the COVID-19 pandemic. *Appl Clin Inform* 2020;11(03):452–459
- 10 Barney A, Buckelew S, Meshierikova V, Raymond-Flesch M. The COVID-19 pandemic and rapid implementation of adolescent and young adult telemedicine: challenges and opportunities for innovation. *J Adolesc Health* 2020;67(02):164–171
- 11 Reeves JJ, Hollandsworth HM, Torriani FJ, et al. Rapid response to COVID-19: health informatics support for outbreak management in an academic health system. *J Am Med Inform Assoc* 2020;27(06):853–859
- 12 Arvais-Anhalt S, Lehmann CU, Park JY, et al. What the coronavirus disease 2019 (COVID-19) pandemic has reinforced: the need for accurate data. *Clin Infect Dis* 2021;72(06):920–923
- 13 Grange ES, Neil EJ, Stoffel M, et al. Responding to COVID-19: the UW Medicine Information Technology Services Experience. *Appl Clin Inform* 2020;11(02):265–275
- 14 Holzer KJ, Lou SS, Goss CW, et al. Impact of changes in EHR use during COVID-19 on physician trainee mental health. *Appl Clin Inform* 2021;12(03):507–517
- 15 Della Monica A, Ferrara P, Dal Mas F, Cobiainchi L, Scannapieco F, Ruta F. The impact of Covid-19 healthcare emergency on the psychological well-being of health professionals: a review of literature. *Ann Ig* 2022;34(01):27–44
- 16 Gan N. How did Australia flatten its coronavirus curve? Restrictions easing as infection rate continues to fall. *CNN*. May 1 2020
- 17 Field E, Dyda A, Lau CL. COVID-19 Real-time Information System for Preparedness and Epidemic Response (CRISPER). *Med J Aust* 2021;214(08):386–386.e1
- 18 Sullivan C, Wong I, Adams E, et al. Moving faster than the COVID-19 pandemic: the rapid, digital transformation of a public health system. *Appl Clin Inform* 2021;12(02):229–236
- 19 Australian Government, Department of Health. National Notifiable Diseases Surveillance System. 2021. Accessed November 8, 2021 at: <http://www9.health.gov.au/cda/source/cda-index.cfm>
- 20 Queensland Government. Queensland COVID-19 statistics. Accessed November 8, 2021 at: <https://www.qld.gov.au/health/conditions/health-alerts/coronavirus-covid-19/current-status/urgent-covid-19-update>
- 21 Smith TB, Workman C, Andrews C, et al. Effects of psychosocial support interventions on survival in inpatient and outpatient healthcare settings: a meta-analysis of 106 randomized controlled trials. *PLoS Med* 2021;18(05):e1003595
- 22 Congress.gov. H.R.1- American Recovery and Reinvestment Act of 2009. 2021. Accessed November 8, 2021 at: <https://www.congress.gov/bill/111th-congress/house-bill/1/titles>
- 23 Queensland Government Statistician's Office. Queensland population counter 2020. 2021
- 24 Australian Government, Department of Health. The Australian Health System. 2021. Accessed November 8, 2021 at: <https://www.health.gov.au/about-us/the-australian-health-system>
- 25 Queensland Government. Metro North Health. 2021. Accessed November 8, 2021 at: <https://metronorth.health.qld.gov.au/>
- 26 Metro North Hospital and Health Service. Metro North Hospital and Health Service Annual Report 2019–20. 2020
- 27 Sullivan C, Staib A, McNeil K, Rosengren D, Johnson I. Queensland Digital Health Clinical Charter: a clinical consensus statement on priorities for digital health in hospitals. *Aust Health Rev* 2020;44(05):661–665
- 28 Queensland Clinical Senate. The Queensland Digital Clinical Charter. 2019. Accessed November 8, 2021 at: <https://clinicaexcelence.qld.gov.au/sites/default/files/2019-03/qld-digital-clinical-charter.pdf>
- 29 Queensland Government. Queensland Health. Integrated electronic medical record (ieMR). 2021. Accessed November 8, 2021 at: <https://www.health.qld.gov.au/clinical-practice/innovation/digital-health-initiatives/queensland/integrated-electronic-medical-record-iemr>
- 30 Australian Government, Department of Health. Personal protective equipment (PPE) for the health workforce during COVID-19. 2021. Accessed November 8, 2021 at: <https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-covid-19-advice-for-the-health-and-disability-sector/personal-protective-equipment-ppe-for-the-health-workforce-during-covid-19>
- 31 Desselle MR, Kirrane M, Chao IT, et al. Evaluating the safety and effectiveness of novel personal protective equipment during the COVID-19 pandemic. *Med J Aust* 2021;214(11):496–499.e1
- 32 The State of Queensland (Department of Health) annual report 2019–2020. State of Queensland (Queensland Health); 2020
- 33 Metro North Hospital and Health Service. Metro North Hospital and Health Service: Strategy for Inclusive Employee Engagement. 2018
- 34 Schultz K, Vickery H, Campbell K, Wheeldon M, Barrett-Beck L, Rushbrook E. Implementation of a virtual ward as a response to the COVID-19 pandemic. *Aust Health Rev* 2021;45(04):433–441
- 35 Hall JL, McGraw D. For telehealth to succeed, privacy and security risks must be identified and addressed. *Health Aff (Millwood)* 2014;33(02):216–221
- 36 Kaplan B. Revisiting health information technology ethical, legal, and social issues and evaluation: telehealth/telemedicine and COVID-19. *Int J Med Inform* 2020;143:104239
- 37 Black AD, Car J, Pagliari C, et al. The impact of eHealth on the quality and safety of health care: a systematic overview. *PLoS Med* 2011;8(01):e1000387
- 38 Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The impact of mHealth interventions: systematic review of systematic reviews. *JMIR Mhealth Uhealth* 2018;6(01):e23
- 39 Australian Government Department of Health. Coronavirus disease 2019 (COVID-19): CDNA national guidelines for public health units. 2021. Accessed November 8, 2021 at: <https://www1.health.gov.au/internet/main/publishing.nsf/Content/cdna-song-novel-coronavirus.htm>
- 40 Eden R, Burton-Jones A, Staib A, Sullivan C. Surveying perceptions of the early impacts of an integrated electronic medical record across a hospital and healthcare service. *Aust Health Rev* 2020;44(05):690–698
- 41 Hannay JE, Dybå T, Arisholm E, Sjøberg DIK. The effectiveness of pair programming: a meta-analysis. *Inf Softw Technol* 2009;51(07):1110–1122
- 42 Queensland Department of Health COVID-19 - Immediate Support Measures; April 2020. Available at: Microsoft Word - COVID-19 - Queensland Department of Health Immediate Support Measures April 2020 (qmhc.qld.gov.au)

- 43 Queensland Government. Queensland Health. Surveillance Reports. 2021. Accessed November 8, 2021 at: <https://www.health.qld.gov.au/clinical-practice/guidelines-procedures/diseases-infection/surveillance/reports>
- 44 Gibney KB, Cheng AC, Hall R, Leder K. Australia's National Notifiable Diseases Surveillance System 1991-2011: expanding, adapting and improving. *Epidemiol Infect* 2017;145(05):1006-1017
- 45 McMahon B. Interoperability: a personal view. 2017. Accessed November 8, 2021 at: <https://www.digitalhealth.gov.au/newsroom/blogs/interoperability-a-personal-view>
- 46 Williams F, Oke A, Zachary I. Public health delivery in the information age: the role of informatics and technology. *Perspect Public Health* 2019;139(05):236-254
- 47 Gebran SG, Knighton B, Ngaage LM, et al. Insurance coverage criteria for bariatric surgery: a survey of policies. *Obes Surg* 2020; 30(02):707-713
- 48 Manca DP. Do electronic medical records improve quality of care? Yes. *Can Fam Physician* 2015;61(10):846-847
- 49 Australian Government, Office of the Australian Information Commissioner. Health Information. 2021. Accessed November 8, 2021 at: <https://www.oaic.gov.au/privacy/health-information/>
- 50 Ciancarini P, Russo D. The strategic technical debt management model: an empirical proposal. *Open Source Systems*. 2020; 582:131-140
- 51 Singh A, Hess T. How chief digital officers promote the digital transformation of their companies. *MIS Q Exec* 2017;16:1-17