2021

Does Digital Transformation of the Australian Healthcare supply chain improve clinical safety?

Sean Smith
University of Southern Queensland, sean.smith@usq.edu.au

Michael Lane
University of Southern Queensland, michael.lane@usq.edu.au

Mark Toleman
University of Southern Queensland, Mark.Toleman@usq.edu.au

Anup Shrestha
University of Southern Queensland, Anup.Shrestha@usq.edu.au

Does Digital Transformation of the Australian Healthcare supply chain improve clinical safety?

Research-in-progress

Sean Smith
School of Business
University of Southern Queensland
Toowoomba, Australia
Email: sean.smith@usq.edu.au

Michael Lane
School of Business
University of Southern Queensland
Toowoomba, Australia
Email: michael.lane@usq.edu.au

Mark Toleman
School of Business
University of Southern Queensland
Toowoomba, Australia
Email: mark.toleman@usq.edu.au

Anup Shrestha
School of Business
University of Southern Queensland
Toowoomba, Australia
Email: anup.shrestha@usq.edu.au

Abstract

Digital transformation of the healthcare supply chain has the potential to improve clinical safety. The Covid-19 pandemic has exposed major deficiencies in the healthcare supply chain (HSC) such as shortages of Personal Protective Equipment and Vaccines. Many healthcare supply chain processes are manual due to complexity, costs, lack of solutions and minimal capability to benefit from digitization, use of unique identifiers and aggregated data. This study is based the implementation of a digital tool to enable electronic procurement between healthcare providers and their suppliers. An artifact, HSC Clinical Safety Evaluation Model is being developed to measure the key clinical safety indicators both pre and post digital transformation of an important component of the healthcare supply chain for small to medium healthcare providers. The results of this study will produce an empirical evaluation model for use by healthcare service providers. The findings are expected to confirm that digital transformation of the healthcare supply chain improves clinical safety. This study will provide healthcare organisations a framework and tools to measure and work towards digitally improving their healthcare supply chains to increase clinical safety.

Keywords Clinical Safety, Evaluation Model, Digital Supply Chains, Australian Healthcare Sector

1 Introduction

The management of supply chains has benefited from digital transformation in many sectors. The significant development, growth and integration of Information Systems (IS) provide considerable opportunities for benefits in many organisations (Sinha et al. 2020). Digital transformation is only expected to further accelerate over the coming years (Hartley and Sawaya 2019; Preindl et al. 2020). Within the healthcare supply chain, digital transformation refers to the disruptions caused by digital technologies changing the value creation paths (Vial, 2019). Clinical Safety can be described in terms of reduced risk, fewer adverse events and improved patient outcomes (Snowdon and Tallarigo 2018). However, the impact of the healthcare supply chain on clinical safety has not been investigated in the literature in detail (Smith et al. 2017).

Despite the vast breadth and depth of improvement in supply chains in general through digital transformation, the healthcare sector remains slow in uptake, adoption and implementation of digital supply chains. Much of the literature identifies the healthcare supply chain (HSC) as being considerably more complex than other sectors and with many more stakeholders (Abdulsalam et al. 2015; Senna et al. 2019). Consequently, the uptake of technology and digital transformation across the healthcare sector overall remains slow (Hermes et al. 2020). When compared to other industries such as finance and retail, the healthcare supply chain has been slow to progress due to competing priorities and drivers between buyers and suppliers (Kritchanchai et al. 2019).

Healthcare systems around the world are striving to increase the safety and quality of services while simultaneously reducing costs and increasing efficiencies (Lin et al. 2014; Rakovska and Stratieva 2018; Senna et al. 2019). Few would argue that we should not strive for the highest levels of safety in our clinical care. Continuous quality improvement is now imbedded in healthcare governance, systems and processes (Australian Commission on Safety and Quality in Health Care 2017). Healthcare is a highly regulated industry in Australia, with many checks and balances to ensure the delivery of safe and effective care from primary to quaternary and across the community.

Some of the barriers to digital transformation in the healthcare supply chain have been a result of budget and strategy constraints of small to medium healthcare providers (Rakovska and Stratieva 2018). As identified by McKinsey (2012), there have also been challenges due to a lack of unique identifiers, a lack of universal electronic messaging and minimal integrative planning to facilitate digital transformation of the supply chain. There is an opportunity to utilise a digital supply chain management tool that provides universal capability for healthcare organisations to trade electronically. The tool addresses many of the challenges such as cost, user interoperability and universal connectivity. The tool provides healthcare providers and in particular, small to medium enterprises, the ability to implement electronic procurement.

Seminal work by Hevner et al. (2004), described Design Science Research (DSR) as the process by which innovative artifacts are created to answer questions that address important real-world problems and contribute to the body of knowledge. This methodology addresses the questions of clinical safety that are impacted by the HSC and provides a model for evaluation of clinical safety for a digital HSC. A key theme of this project is digital transformation, and the use of a digital enabler provides an opportunity to measure both pre and post digital transformation intervention on clinical safety.

A number of studies have shown the benefits which may be realised through digital transformation of the supply chain. Lin et al. (2014), Kaefer and Bendoly (2004) and Smith and Correa (2005) have each identified benefits however these do not include any potential clinical benefit arising from the HSC. This research intends to build a ***Clinical Safety Evaluation Model*** as an artifact that measures the impact of digital transformation of the HSC on clinical safety. This model will provide healthcare organisations with an ability to map key HSC indicators to demonstrate clinical safety.

The research will use real world case studies to demonstrate the use of the evaluation model. The case studies are expected to provide data showing that the use of a digital supply chain management tool in the Australian healthcare system will improve clinical safety. The outcomes of this study are therefore twofold. Firstly, the design and implementation of a clinical safety evaluation model for use in the Australian healthcare digital supply chain. Secondly, this study will provide evidence that digital transformation within the healthcare supply chain can improve clinical safety.

The outcomes of this study are expected to inform the better management of healthcare supply chains through measurement and potential benchmarking across industry. The Clinical Safety Evaluation Model will provide evidence and potential support for the further implementation of digital solutions within the healthcare supply chain to improve patient safety. The theoretical contribution of the study

may provide foundational elements for further research and development as well as integration with other existing safety standards such as future editions of the National Safety and Quality Health Service Standards.

2 Literature review

2.1 Digital transformation of Healthcare Supply Chain

The healthcare supply chain (HSC) can be differentiated from other industry supply chains due to the unique nature of its drivers. Senna et al. (2019) suggest that unlike other supply chains which seek to increase profits, the main objective of the HSC is to save lives. Kritchanchai and Suwandechochai (2010) also contend that unlike a production process, healthcare actually has many different supply chains crossing over each other. Abdulsalam et al. (2015) have recognised the large number of stakeholders in the HSC as unusual in supply chains. The stakeholders may be as diverse as patients, nurses, doctors, governments, insurers, healthcare managers and suppliers. The range, criticality as well as complexity of products has also been credited with adding to the HSC uniqueness. Abdulsalam et al. (2015) also acknowledge that although other supply chains may be influenced by some of these attributes the HSC is unique in its collective characteristics and interactions.

Aggarwal and Travers (2001) identified some of the challenges facing the healthcare supply chain and the potential for improvement using digital technologies. The main focus of their research discussed the use of e-commerce however they also explored integration with, and links to, other key systems within the healthcare sphere. Bhakoo and Chan (2011) ascertain that the process of implementing systems in the HSC is complex due to the need for participation and required buy-in of many stakeholders. They go on to highlight the importance of the work performed by the National e-Health Transition Authority (NeHTA) in providing the foundational elements of standardised identification, messaging and the National Product Catalogue to enable HSC reform in Australia (Bhakoo and Chan 2011).

Vial (2019) suggests that successful digital transformation requires not only the right technology but also the right strategy and organisational change management approach. In agreement with both Bhakoo and Chan (2011) and Lee et al. (2011), Vial (2019) emphasises the importance of collaboration between all stakeholders. Many of the barriers to HSC efficiency are replicated in digital transformation in healthcare in general. Complexities, budget constraints, system capabilities and multiple stakeholders are the key shared challenges (Hermes et al. 2020).

Across the healthcare supply chain there is significant evidence of digital transformation in manufacturing, logistics and procurement (Laurenza et al. 2017). Several studies have looked at the benefits of digital transformation in the healthcare supply chain, however these are generally business-focused metrics such as cost savings and efficiencies that rarely consider the benefits of clinical qualities such as enhanced clinical safety. Many of the financial and efficiency benefits have arisen through the use of e-commerce and/ or e-procurement using Electronic Data Interchange (EDI) (Lin et al. 2010). Other benefits may be realised by using standardisation and automation in identification and data sets such as through the results of work performed by NeHTA (now known as the Australian Digital Health Agency (ADHA)). Unique identifiers, for example, GS1 Global Trade Item Numbers (GTINs, often represented as barcodes), enable the better use of data electronically in healthcare including access and integration with clinical records (Brommeyer 2014).

In Australia, most State and Territory health departments have deployed varying forms of digital transformation in their supply chains however smaller, non-government providers are challenged by the financial and technical requirements of these types of solutions (Productivity Commission 2021). Many suppliers provide proprietary electronic shopping cart systems for their buyers however, it could be argued that these have minimal use for the buyer beyond placing stock orders with that designated supplier.

2.2 Clinical Safety

The term Clinical Safety may be used to explain practices which include patient safety, clinical quality and clinical risk management. The Australian Commission on Safety and Quality in Health Care (2017, p. 1) in the National Safety and Quality Health Service Standards (2nd Ed) states that the main objective of clinical safety is to "…to protect the public from harm and to improve the quality of health service provision". For Australian healthcare organisations assessed and accredited on this foundation of safety and quality, these concepts are the main drivers of healthcare service provision.

Farrokhvar (2013) suggests that clinical or patient safety may be seen as the absence of adverse events including the recognition of near misses, active and latent errors. Supply chain related adverse events in healthcare are predominantly due to inventory discrepancy (lack of correct stock) and performance deficiencies particularly in regard to recall, return and expired stock (Farrokhvar 2013). Buyurgan and Farrokhvar (2015) conducted further studies to identify adverse events that can be attributed to the HSC such as increased patient risk, delayed care and insufficient product availability. Chiu et al. (2020) recognised that a significant number of actual or potential adverse events are missed or not accurately reported and estimate that up to 70% of faults occur due to human error, lending further weight to the need for standardisation and use of digital technologies in the HSC wherever possible.

The clinical safety of patients is clearly influenced by the health care supply chain when viewed in the context of contaminated medicines, emergency stock shortages and medical device recalls (McKinsey 2012). The availability of the right product, for the right patient, at the right time and in the right place is critical for the provision of safe health care. The governance of products by regulators such as the Therapeutic Goods Administration (TGA) go a long way towards ensuring clinical safety; however, this is just one component of the healthcare supply chain. The Covid-19 vaccination strategy in Australia is one topical example of how a disrupted supply chain impacts on potential patient safety due to changing clinical recommendations and a failure of stock availability (Fonseca and Azevedo 2020).

Based on the authors knowledge and literature review, there does not appear to be any mechanism in Australia to evaluate healthcare organisations in relation to the impact of the HSC supply chain on clinical safety. Smith et al. (2017) found that measures such as quality in the healthcare supply chain have not been a strong feature in the literature. Existing tools such as the National Safety and Quality Health Service Standards (Australian Commission on Safety and Quality in Health Care 2017) do not specifically measure HSC components. This gap in existing evaluation methodologies or tools presents a potential loss of improvement in clinical safety.

3 Research methodology

The methodology employed in this study is a Design Science Research (DSR) approach to create and test an artifact (Hevner et al. 2004) to evaluate clinical safety in a healthcare supply chain that has been digitally transformed. The suitability of this research methodology is twofold; in producing an evaluation model to adapt, build on or utilise improved clinical safety in a HSC and capturing the empirical evidence to measure both the effectiveness of the artifact, HSC Clinical Safety Evaluation Model and its design. The intent is to not only provide evidence of the effectiveness of the artifact and its design but to also provide a documented way of implementing the artifact to realise the benefit of improved clinical safety. In this research project, an artifact (HSC Clinical Safety Evaluation Model) will be designed and implemented to measure the impact of digital transformation on the healthcare supply chain in relation to clinical safety measures.

DSR was chosen because the approach enables key concepts in several different realms to be analysed in comparison. DSR provides a mechanism to address both design research and behavioural research (Hevner and Chatterjee 2010). Figure 1 illustrates the adapted Design Science Research Model (Hevner, 2004). The methodology enables the integration of factors through a mixed methods study.

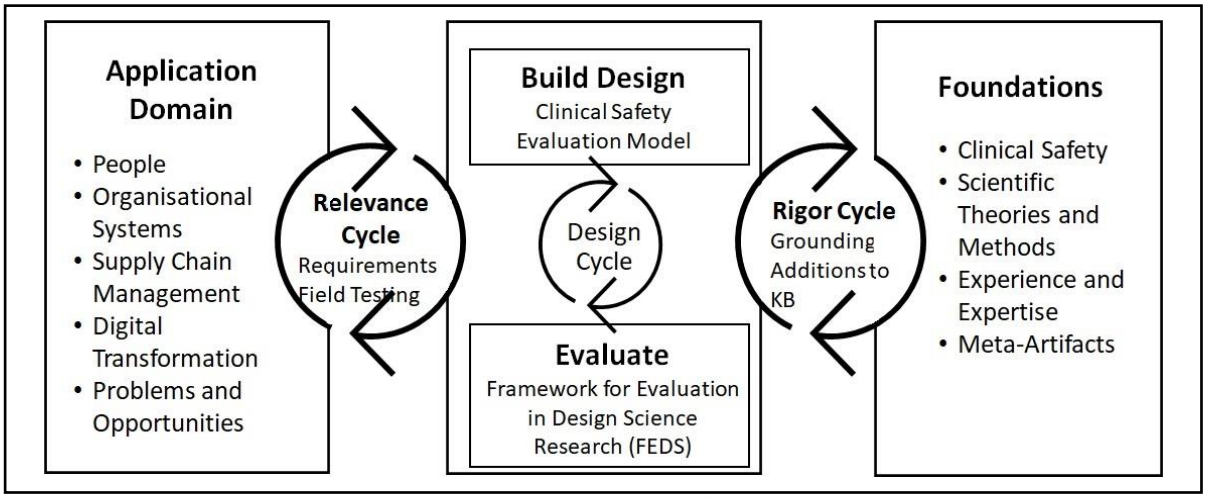

Figure 1: Design Science Research Model (adapted) (Hevner 2004)

The mixed methods used in this research is guided by a Design Science approach to develop the HSC Clinical Safety Evaluation Model measures which incorporate a number of information system and clinical attributes to provide a quantitative dataset to establish the impact on clinical safety. This will be cross analysed with the results of Semi Structured Interviews (SSI) with end users from each participant organisation to identify additional causal or thematic elements and support for the quantitative data.

The study will be conducted in a three phased approach:

1A Development of universal electronic trading platform- digital enabler (complete)

1B Development of conceptual framework for an Evaluation Model- [Artifact] (in progress)

2 Demonstration of the Evaluation Model through a mixed-methods study

3 Further Revision and Promotion of the artifact for clinical consumption

The digital enabler is a universal electronic trading platform (UETP) which provides healthcare providers with a tool to engage in the electronic procurement process with their suppliers. The UETP has been designed to meet key healthcare supply chain standards in Australia following the reforms implemented through the Brommeyer (2014). The UETP enables the secure electronic sharing of procurement information utilising unique identifiers for product and location. The identifiers and e-procurement standards provide visibility and systematisation for healthcare providers to manage their supply chain. The UETP is an enabler for digital transformation of key HSC concepts.

The impact of the UETP will be measured using the artifact- a Clinical Safety Evaluation Model which is designed to capture critical information regarding the impact on the HSC in relation to clinical safety. The National Safety and Quality Health Service Standards (NSQHS) (2nd Edition) have been analysed to extract the criteria that are most applicable to the HSC. These criteria consist of the four main foci of Measurements, Identifiers, Environment and Systems and are derived from the Clinical Governance Standards 1.8, 1.10, 1.17 and 1.29 (Australian Commission on Safety and Quality in Health Care 2017). A further 15 subsets of these foci have been developed and current work will integrate with key aspects of the DeLone and McLean Information Systems Success Model (DeLone and McLean 2014). The DeLone and McLean Model utilises six dimensions addressing System Quality, Information Quality, Service Quality, Use, User Satisfaction and Net Benefit. The DeLone and McLean model has been previously used in research both in supply chains and in healthcare (Booth 2012; Fiaz 2018). The versatility of the model provides a proven solution to measure domains of this study (Ji et al. 2021).

The artifact will be evaluated using the Framework for Evaluation in a Design Science Research (FEDS) model (Venable et al. (2016). The FEDS model provides a rigorous assessment of artifacts regarding their effectiveness. This is a key aim for an electronic solution to enable digital transformation of the HSC with potential influence on clinical safety. Formalisation of the Evaluation Model will consist of localisation and population of key functional areas of the digital enabler in the first phase through a structured interview and first application of the artifact. This formalisation will involve a range of healthcare providers in general practice and other clinical delivery. The study seeks to recruit a minimum of ten (10) small to medium organisations for the formalisation process. Structured interviews will record end user feedback on their perception of safety in clinical care and the role of the HSC within the study organisations in that regard. A concurrent design will enable collection of mixed methods data simultaneously to cross validate and compare the findings (Leavy 2017).

Following the DSR iterative design process, the findings are expected to drive further revisions of the HSC Clinical Safety Evaluation Model for greater use across a broad selection of healthcare providers. The fine tuning of the HSC Clinical Safety Evaluation Model artifact is expected to provide a mechanism to enable healthcare providers to baseline current supply chain processes, identify deficiencies and determine improvements that lead to clinical safety.

4 Next Steps of Research Process

In this Research-In-Progress paper, the first stage of the project is presented. The digital transformation enabler of HSC and the HSC Clinical Safety Evaluation Model as a conceptual framework have been explained. The next stage will include a pilot study of both the enabler of HSC and the HSC Clinical Safety Evaluation Model. The results of the pilot study will provide functional and structural feedback prior to undertaking the full study. The research is expected to inform future clinical use of the artifact HSC Clinical Safety Evaluation Model, a key contribution to the knowledge bases of healthcare supply chain and to providing improvements in clinical safety. The research will provide healthcare organisations with the ability to measure their current HSC clinical safety status, identify areas for

potential improvement and may inform business cases for digital enhancements of the HSC to further improve clinical safety.

5 References

Abdulsalam, Y., Gopalakrishnan, M., Maltz, A., and Schneller, E. 2015. "Health Care Matters: Supply Chains in and of the Health Sector," *Journal of business logistics* (36:4), pp. 335-339.

Aggarwal, A. K., and Travers, S. 2001. "E-Commerce in Healthcare: Changing the Traditional Landscape," *Journal of Healthcare Information* (15:1), pp. 25-36.

Australian Commission on Safety and Quality in Health Care. 2017. "National Safety and Quality Health Service Standards, 2nd Ed.." Sydney: ACSQHC.

Bhakoo, V., and Chan, C. 2011. "Collaborative Implementation of E-Business Processes within the Health-Care Supply Chain: The Monash Pharmacy Project," *Supply chain management* (16:3), pp. 184-193.

Booth, R. G. 2012. "Examining the Functionality of the Delone and Mclean Information System Success Model as a Framework for Synthesis in Nursing Information and Communication Technology Research," *Computers, informatics, nursing* (30:6), pp. 330-345.

Brommeyer, M. 2014. "The Australian Supply Chain Reform Agenda - Now and Then," in: *GS1 Healthcare Conference* M. Brommeyer (ed.). Seoul, South Korea: National e-Health Transition Authority.

Buyurgan, N., and Farrokhvar, P. 2015. "Supply Chain-Related Adverse Events and Patient Safety in Healthcare," *International journal of healthcare information systems and informatics* (10:2), pp. 14-33.

Chiu, W.-H., Luong, C.-Q., and Chi, H.-R. 2020. "Shedding Light on Hospital Service Failure: Findings from Taiwanese Medical Qcc," *Total quality management & business excellence* (31:15-16), pp. 1718-1737.

DeLone, W. H., and McLean, E. R. 2014. "Measuring E-Commerce Success: Applying the Delone & Mclean Information Systems Success Model," *International Journal of Electronic Commerce* (9:1), pp. 31-47.

Farrokhvar, P. 2013. "Patient Risk and Data Standards in Healthcare Supply Chain." ProQuest Dissertations Publishing.

Fiaz, M. 2018. "Enterprise Resource Planning Systems: Digitization of Healthcare Service Quality," *Administrative sciences* (8:3/38), pp. 1-12.

Fonseca, L. M., and Azevedo, A. L. 2020. "Covid- 19: Outcomes for Global Supply Chains," *Management & Marketing. Challenges for the Knowledge Society* (15:s1), pp. 424-438.

Hartley, J. L., and Sawaya, W. J. 2019. "Tortoise, Not the Hare: Digital Transformation of Supply Chain Business Processes," *Business horizons* (62:6), pp. 707-715.

Hermes, S., Riasanow, T., Clemons, E. K., Böhm, M., and Krcmar, H. 2020. "The Digital Transformation of the Healthcare Industry: Exploring the Rise of Emerging Platform Ecosystems and Their Influence on the Role of Patients," *Business Research* (13:3), pp. 1033-1069.

Hevner, A. R., and Chatterjee, S. 2010. *Design Research in Information Systems : Theory and Practice*. New York: Springer.

Hevner, A. R., March, S. T., Park, J., and Ram, S. 2004. "Design Science in Information Systems Research," *MIS quarterly* (28:1), pp. 75-105.

Ji, M., Yu, G., Xi, H., Xu, T., and Qin, Y. 2021. "Measures of Success of Computerized Clinical Decision Support Systems: An Overview of Systematic Reviews," *Health policy and technology* (10:1), pp. 196-208.

Kaefer, F., and Bendoly, E. 2004. "Measuring the Impact of Organizational Constraints on the Success of Business-to-Business E-Commerce Efforts: A Transactional Focus," *Information & Management* (41:5), pp. 529-541.

Kritchanchai, D., Krichanchai, S., Hoeur, S., and Tan, A. 2019. "Healthcare Supply Chain Management: Macro and Micro Perspectives," *Logforum* (15:4), p. 8.

Kritchanchai, D., and Suwandechochai, R. 2010. "Supply Chain Management in Health Sector in Thailand: A Case Study," *International journal of services, economics and management* (2:2), p. 211.

Laurenza, E., Quintano, M., Schiavone, F., and Vrontis, D. 2017. "The Effect of Digital Technologies Adoption in Healthcare Industry: A Case Based Analysis," *Business process management journal* (24:5), pp. 1124-1144.

Leavy, P. 2017. *Research Design : Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches*. New York, UNITED STATES: Guilford Publications.

Lee, S. M., Lee, D., and Schniederjans, M. J. 2011. "Supply Chain Innovation and Organizational Performance in the Healthcare Industry," *International journal of operations & production management* (31:11), pp. 1193-1214.

Lin, C., Lin, H., Huang, Y., Jalleh, G., Liu, Y., and Ching-Ju Chao, S. 2014. "Towards a B2b E-Commerce Evaluation Management Model to Assess Organizational Drivers in Hospitals," *The International Technology Management Review* (4:3), pp. 115-132.

Lin, C., Liu, Y., Feng-Chia, L., Jalleh, G., Huang, Y.-A., and Jhuang, Z.-R. 2010. "B2b E-Commerce Adoption and Implementation Constraints and Critical Success Factors in the Healthcare Organizations," in: *Conference On Ubiquitous Information Management And Communication*. ACM, pp. 1-10.

McKinsey. 2012. "Strength in Unity: The Promise of Global Standards in Healthcare."

Preindl, R., Nikolopoulos, K., and Litsiou, K. 2020. "Transformation Strategies for the Supply Chain: The Impact of Industry 4.0 and Digital Transformation," *Supply chain forum* (21:1), pp. 26-34.

Productivity Commission, C. G. o. A. 2021. "Vulnerable Supply Chains."

Rakovska, M. A., and Stratieva, S. V. 2018. "A Taxonomy of Healthcare Supply Chain Management Practices," *Supply chain forum* (19:1), pp. 4-24.

Senna, P., Reis, A., Santos, I. L., Dias, A. C., and Coelho, O. 2019. "A Systematic Literature Review on Supply Chain Risk Management: Is Healthcare Management a Forsaken Research Field?," *Benchmarking : an international journal* (28:3), pp. 926-956.

Sinha, A., Bernardes, E., Calderon, R., and Wuest, T. 2020. *Digital Supply Networks : Transform Your Supply Chain and Gain Competitive Advantage with Disruptive Technology and Reimagined Processes*. Place of publication not identified: McGraw-Hill.

Smith, A. D., and Correa, J. 2005. "Value-Added Benefits of Technology: E-Procurement and E-Commerce Related to the Health Care Industry," *International journal of health care quality assurance* (18:6), pp. 458-473.

Smith, B. K., Nachtmann, H., and Pohl, E. A. 2017. "Quality Measurement in the Healthcare Supply Chain," *Quality Management Journal* (18:4), pp. 50-60.

Snowdon, A. W., and Tallarigo, D. 2018. "Leveraging Supply Chain Infrastructure to Advance Patient Safety in Community Health-Care Settings," *Leadersh Health Serv (Bradf Engl)* (31:3), pp. 269-275.

Venable, J., Pries-Heje, J., and Baskerville, R. 2016. "Feds: A Framework for Evaluation in Design Science Research," *European Journal of Information Systems* (25:1), pp. 77-89.

Vial, G. 2019. "Understanding Digital Transformation: A Review and a Research Agenda," *The journal of strategic information systems* (28:2), pp. 118-144.