

2020

## Digital Technologies as antecedents to Process Integration and Dynamic Capabilities in Healthcare: An Empirical Investigation

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### Recommended Citation

Chakravorty, Tulika; Jha, Karunakar; Barthwal, Sunil; and Chakraborty, Samyadip (2020) "Digital Technologies as antecedents to Process Integration and Dynamic Capabilities in Healthcare: An Empirical Investigation," *Journal of International Technology and Information Management*. Vol. 28 : Iss. 4 , Article 4.

Available at: <https://scholarworks.lib.csusb.edu/jitim/vol28/iss4/4>

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# Digital Technologies as antecedents to Process Integration and Dynamic Capabilities in Healthcare: An Empirical Investigation

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## ABSTRACT

*Healthcare has been in focus over the past decade due to its criticality and continuous revolution. In this digital era, with the advent of various technologies, healthcare is undergoing a massive transformation. This study attempts to analyze the impacts of three major digital technologies which are being adopted in the healthcare sector which are electronic medical records (EMR), enterprise resource planning (ERP) and internet-of-things (IoT) enabled medical wearables in the hospital context. Focusing towards analyzing the impact of these technologies towards process-integration and further towards dynamic capabilities like quality, agility and responsiveness; the study framework is well-grounded by two theoretical-underpinnings - Cybernetic Control theory and Dynamic Capability theory. Questionnaire has been finalized through extant literature review and focused-group-discussion. Empirical investigation has been done with a sample of 154 hospital respondents from four major metro cities from the private tertiary-care hospitals in India. The empirical analysis of the framework is carried out by exploratory-factor-analysis, confirmatory-factor-analysis and structural-equation-modelling. The study outcomes highlight linkages both from technologies to process-integration and further towards dynamic capabilities. This study uniformly*

*analyzes the impacts of the aforementioned digital technologies across Indian private hospitals thereby providing the hospital managers with a framework, influencing superior dynamic capabilities and achieving a competitive edge.*

**Keywords:** EMR, ERP, IoT-Wearables, Process-Integration, Healthcare, Treatment-Quality, Agility, Responsiveness

## INTRODUCTION

Digital technologies are one of the major breakthroughs in transformations of the world. Each and every sector is getting automated with technology adoption and heading towards growth, healthcare is also evolving with this change. Effective use of digital technologies has been cited as the key drivers for achieving competitive edge by the healthcare providers (Heart et al., 2017; Farahani et al., 2018; Fiaz et al., 2018). Healthcare is juggling between better treatments and integrating the operational systems which are in-silos. Healthcare being a highly critical sector essentially needs for on-time and reliable information flow, which is the key for patient treatment and saving human lives. Technologies like Electronic Medical Records (EMR), Enterprise Resource Planning (ERP) and Internet of Things (IoT)-Wearables are rising as buzzwords for digitalization of the healthcare sector.

The digitalized form of patients' medical or health records are referred to by various terminologies like electronic health records (EHR), electronic medical record (EMR) and electronic patient records (EPR) are often used interchangeably. The generic meaning of these terminologies indicates all forms of digitalized patient data including images, clinical reports, scanned prescription, etc. which may be used for any form of patient identification and processing. Hospitals are strongly focusing on conversion of manual paper-based patient records to an electronic mode for an improved seamless handling of patients' medical records. The key focus is towards real-time information sharing, coordination, competitive quality services and value-based care to the patients. ERP implementation in the hospitals has come up largely as the major need for cross-functional coordination across systems. ERP systems are the technology platform which potentially integrates and automates the functions and the planning systems of the functional departments. Gradually, ERP systems are also creeping in the healthcare systems as well which promisingly improves real time information sharing. At this juncture, usage of IoT-enabled medical wearables are also transforming the sector where the hospitals can be digitally connected with their patients through devices across locations and can provide treatment even from virtual locations and need to be physically present at a particular location. Wearable technologies have touched almost every enterprise vertical market. Companies and institutions in multiple industries are closely

evaluating how wearables can bring speed, efficiency, lower costs, and improved workflows for their operations. Healthcare sector is also largely picking up towards medical IoT enabled wearables for a wide range of healthcare observations. In the age of mobile applications and constant connectivity, today's patients' expectations are much more beyond conventional treatment process with the same level of technology and on-demand information in a healthcare environment as they have at home. Immersed in the world of integrated, interconnected networks via the IoT, various medical-wearables such as wearable activity trackers, wristband for tracking heart rate or blood pressure, wearable ECG-monitors, neurometers, automated asthma monitoring device, etc. are gradually helping the medical systems to bring mobility, interoperability and dynamic treatment capabilities even from remote locations. Although these technologies are gradually creeping in the healthcare systems but there is a major need to streamline the workflow (Chakravorty et al., 2019) which are currently in isolation. In order to run a successful practice, today's healthcare organizations need qualified providers to maintain a seamlessly integrated workflow for better treatment. This paper focusing on the technology implementations in healthcare perspective highlights the potential problems of healthcare digitalization and further analyses them on the basis of detailed literature review and theoretical background. The following section discusses the problems of healthcare digitalization.

### ***Problems in healthcare digitalization***

Healthcare system includes hospitals, medical devices, clinical trials, outsourcing, telemedicine, medical tourism, health insurance and medical equipment.<sup>1</sup> Out of the various stakeholders; hospital activities form the lion's share across the healthcare supply chain (Schneller and Smeltzer, 2006). Various developing countries are not having the infrastructure of being completely tech-integrated. Hospital activities are largely dependent on the relationships and interactions with the suppliers. India is one of the largest developing economies in the world; which according to National Health Policy of India (NHPI, 2017) is largely focusing on the digital integration, care-affordability, quality care provisions, value-based patient care and patient- satisfaction. Indian healthcare system is also undergoing transformation as triggered by government initiatives of Digital India and Aadhaar, the private healthcare sector has launched various mobile applications, telemedicine tools, and innovations centres throughout the country (NHPI, 2017)<sup>2</sup>. Electronic-health (e-health) and Mobile-Health (m-health) is also growing in India with a projected market size of 416 million USD in 2015, which is set to increase to 1

Billion USD INR by 2020; and studies presented that 68% of doctors in developing countries like Brazil, India, and China recommend m-Health (IBEF Report, 2019)<sup>1</sup>. In spite of the national visions, various issues are observed in healthcare deliveries like servicing capability, supplier-hospital linkages, and care-quality issues for patients (Sarbadhikari, 2019). Although, electronic medical records have increased the convenience and feasibility of healthcare management but various physicians and consumers are not very proficient, in to these technology resources as they require much more awareness and understanding to use them and also it interferes in existing routines which brings a reluctance to change (Mathai et al., 2017). The hospital working staffs and managers are not completely aware of the business benefits and get disturbed with the updates and notifications in the electronic format. Currently, disorganized EHR design is obstructing the workflow of physicians and needs to be properly designed and used with the IoT enabled systems. Major issues and focuses are towards creating a well- functioning system, coordination and integration among the hospitals and suppliers, envisioning a well-connected, information-rich and patient-centric healthcare delivery system<sup>3</sup> where digital integration plays a vital role. The health integration system being weak and fragmented forms a major obstacle which is leading to insufficient vigilance for health crises. Technology systems like ERP, being the software package tools are focused for functional integration of the system (Kelle and Akbulut, 2005).

Extant literature has highlighted that healthcare needs a transition towards patient-centric care with mobility and integration where the stakeholders such as hospital, patient, and service staffs need to be seamlessly connected with each other to form a well-integrated system (Garefalakis et al., 2016). This patient-centric IoT e-Health and m-health (mobile-health) ecosystem needs technology integration systems like ERP, electronic medical systems (EMR) and working on the processes like integration in the healthcare systems which has been a major drawback (Baig et al., 2017; Baker et al., 2017; Farahani et al., 2018). Moreover proper awareness regarding EMR- Implementation, ERP-Implementation and IoT-wearables usages and their business implications need to be provided to all the healthcare providers (Farahani et al., 2018). With this backdrop, it is very important to properly elaborate

<sup>1</sup> IBEF Report 2019 <https://www.ibef.org/download/healthcare-jan-2019.pdf>

<sup>2</sup> National Health Policy, 2017: [http://www.pmindia.gov.in/en/news\\_updates/cabinet-approves-national-health-policy-2017/?comment=disable](http://www.pmindia.gov.in/en/news_updates/cabinet-approves-national-health-policy-2017/?comment=disable)

<sup>3</sup> <http://www.pwc.in/industries/healthcare.html>

the detailed view of implementation of EMR, ERP and IoT-enabled wearables usage and analyze the implications of these digital tools adoption in hospitals and provide clarity to the hospital stakeholders as a whole.

### ***Study Objective***

This study attempts to analyze the three major technologies which are EMR, ERP and IoT- enabled medical wearables, highlighting their outcomes and impacts on the process-integration and treatment capabilities like quality, agility and responsiveness in the hospitals. This study also provides a unique relation of these technologies with each other to present a nuanced view of how these technologies combined together enables the hospital-systems to have process- integration and capability outcomes to achieve a competitive advantage; which is backed by empirical findings from Indian tertiary-care hospitals.

This paper is arranged and logically sequenced into sections. It starts with introduction and the problem in healthcare digitalization followed by study objective. The paper grounds itself into the theoretical underpinning which establishes the theory to extant literature linkages. The next section provides an extensive literature review on extant studies and practitioners' literatures. The subsequent section the highlights the testable construct linkages leading to hypotheses development and finally a detailed research methodology section followed by results, discussion and analysis of the study.

Based on the problem areas and study objectives the paper is backed by theoretical underpinnings which provide background and details of research with underlying theories. The theories involved in this study have been used as the formation of study framework.

## **THEORETICAL BACKGROUND**

The study is conceptualized and grounded in two relevant theories. The theories which are applied as the backbone of this study are 'Cybernetic Control Theory' and 'Dynamic Capability Theory'. These theories are further linked to the conceptualization of the study framework to propose the study model.

### ***Cybernetic Control Theory***

Cybernetic control theory (CCT) provides a view on how cyber resources (EMR, ERP & IoT systems as described in this study) offer a means by which managers

can effectively develop their various strategies and organizational capabilities (Vancouver, 1996). The theory emphasizes on the concepts of receiving timely feedback, analyzing deviations from expectations and taking necessary decisions to correct any deviations. Consistent with this theory, the digital resources- EMR, ERP and IoT-wearables provide means by which organizations can capture, process, and deliver real-time information, enhance integration and coordination in the system. These technology resources foster improved quality, agility and responsiveness in the system. This effectively indicates the directional impact of digital technologies towards capabilities.

### ***Dynamic Capability Theory***

Dynamic capabilities (DC) theory by (Teece et al., 1997) suggests that resources implemented in process contribute to capabilities and performance outcomes as they embody dynamic routines that can be manipulated into unique configurations to drive product and service differences and bring in a competitive advantage in the system. Teece and Pisano (1994) developed the area proposing dynamic capabilities theory as the subset of the competences/capabilities to allow the firm to create new products and improved processes and respond to dynamic market conditions. This study thus highlights the impacts of digital resources and their combined effect on each other on the process-integration and dynamic capabilities of the hospitals.

## **LITERATURE REVIEW**

This section discusses a detailed review of extant literature of all the constructs considered in this study.

### ***Review of the Digital-Tools***

The three digital tools which have been emphasized in the healthcare sector and considered in this study are- EMR, ERP & IoT-enabled wearables. This section reviews the importance of these technologies from extant literature.

### ***EMR-Implementation***

Electronic Medical Records (EMR) is an electronic tool for managing patient's health/medical records which include diagnostic reports, physician and notes, laboratory test results, electronic prescriptions, electronic reminder systems, etc. (Keyhani et al., 2008; Dobrzykowski and Tarafdard, 2017). EMR-Implementation

offers a platform for digital storage of patient-data enhancing availability, transparency and integration of information by sharing the medical records between care-providers (Fong et al., 2015); contributing to an effective way of transforming hospital process by reducing the frequency of consultation, improving accuracy of patient handling, avoiding manual errors or duplicate investigations which was prevalent in manual records keeping (Chakravorty et al., 2019). Deloitte Report (2019)<sup>4</sup> reported that EMR- Implementation in hospitals have formed the nerve-centre of most of the healthcare digitalization process which effectively optimizes, integrated and synchronizes the treatment delivery. EMRs foster real-time information sharing, data-portability and coordination of medical data which has shown great progress in treatment agility, flexibility and quality, further fostering operationalefficiency (Zuckerman, 2017; Chakravorty et al., 2019). EMR maintained in cloud or databases forms the backbone for healthcare analytics and precision medicine initiatives; accelerating research on disease patterns, mechanisms and individualization of medical treatments (Wang et al., 2018). Healthcare systems capture medical information electronically and capture more novel data as Human-DNA which can pave paths of analytics, helping the goals of high-quality, responsive, affordable, and efficient care (Ward et al., 2014). Increased EMR-implementation worldwide is largely paving a stepping stone towards transforming healthcare big data into actionable knowledge (Ross et al., 2014), by integration of routine electronic medical records in a research data platform allowing efficient data collection with collaborative investigations (Sammani et al., 2019).

### ***ERP-Implementation***

Enterprise Resource Planning (ERP) systems are the software technology package which integrates information flows and business processes across the vertical of organizations (HassabElnaby et al., 2012). ERP systems scope in the hospital context includes healthcare-data with patients, hospital departments, stakeholders and suppliers; thereby fostering a seamless real-time integrated platform (Mucheleka and Halonen, 2015). This technology has got the potential to boost the efficiency, healthcare service quality, productivity and service cost reduction (Fiaz et al., 2018). Yang et al. (2015) emphasized that the usage of technologies like ERP in healthcare potentially improves the quality by integrating and automating the healthcare functionalities. ERP integrated all the business modules across departments, silos, partners and properly aligns the business processes; thereby fostering connectivity, clarity and transparency (HassabElnaby et al., 2012). The

<sup>4</sup> <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/life-sciences-health-care/deloitte-uk-connected-health.pdf>



criticality and complexity of healthcare sector with human life at stake makes ERP implementation and its utility much more important especially in hospital operations as hospital enterprise platforms are information intensive and dealing with large volumes of highly dynamic patient data (Dobrzykowski and Tarafdar, 2015). Garefalakis et al. (2016) highlighted that ERP- Implementation in hospitals minimize the lead-time, lessen the vagueness in information sharing, reduce waiting times and avoidable delays and also overstocking or stock-outs of essentials in the hospitals; thereby increasing efficiency, productivity and better treatment delivery. Studies have emphasized on the success of ERP-Implementation in ensuring superior care-quality and better patient servicing capability (Mucheleka and Halonen, 2015; Fiaz et al., 2018).

### ***IoT-Wearables Usage***

Internet of things (IoT) are broadly indicated as network of devices or systems involving integrating platform for hardware, computing devices, physical objects, software, etc. over a network fostering interaction, communication, collection and exchange of data (Chakraborty et al., 2019). With the technology advancements happening day by day, wearable medical devices enabled by IoT are playing a significant role in the healthcare industry by offering the information that is essential for the patients to increase integration and mobility. Due to advanced IoT-adoption, many wearable devices have moved to real-time patient monitoring from the wellness segment in recent years (Farahani et al., 2018). IoT-enabled wearable devices facilitate physicians and patients to remain accessible to the cloud for transmitting data and integrating the process; thereby enabling healthcare providers to gain the information they require, ensure regulatory compliance by protecting patient data and gain much better insight into the healthcare. Flexible electronic medical wearables like pedometers, cuff-less blood pressure meters, smart-inhalers, ring-type heart rate monitor, Bluetooth-based ECG monitor, blood oxygen saturation measure devices, blood glucose meters, etc. are tailored towards quantifying important data for people with diseases like asthma, cardiac diseases or diabetes and enhances mobility in health status by fostering earlier guidance and diagnosis (Li et al., 2019). Medical wearables aid towards a vast direction of human and operator coordination and also create value by storing the medical data for further analysis and decision making. IoT wearables generate sensor-based information which has the ability to provide seamless real-time integration with online social networks (Metcalf et al., 2016). IoT-enabled medical wearables increase efficiency of the hospitals by reducing patient stays, provide more accurate treatment, and improve the link between medical providers and patients (Gosink et al., 2019).

### ***Process Integration***

Healthcare sector is a combination of several stakeholders which are highly fragmented. Process Integration is indicated as the extent to which the organizations can coordinate the flow of information, materials and finances across departments, stakeholders or partners not only at the intra-level but also at the inter-level for real-time process coordination and information sharing in order to process seamlessly (Rai et al., 2006). The factors influencing Supply chain integration in the hospitals are highlighted as trust, knowledge exchange and IT-integration across the supply-chain stakeholders (Afshan and Sindhuja, 2015). With the advent of digital technologies in healthcare integration and standardization of the process has become increasingly important to the overall effort to achieve better health outcomes for patients (Bradley et al., 2012). Infrastructure integration using technology resources consists of connectivity and compatibility which refers to ability to connect inside or outside the organizational environment and interoperate and share data or information with other elements. Extant literatures have shown the importance and advantages of digital technologies to integrate the supply chain processes and enhance visibility throughout the system. Miller and Sim (2004) highlighted that healthcare providers including the clinicians, hospital managers, physicians, nurses, etc. are largely in need of real-time information sharing and urgent usage of high-end medical technology and associated device platforms, thereby aiming towards improving the quality of care delivery. Dobrzykowski and Tarafdar (2015) suggested that information exchange between the healthcare stakeholders (namely hospital staffs, physicians and patients) has been instrumental for successful healthcare delivery and its synchronous continuity and integration.

### ***Dynamic Capabilities***

Dynamic Capabilities (DC) are indicated as firms interest towards inculcating differentiating abilities and strengthening their abilities for a competitive advantage (Winter, 2003). It often emphasizes the abilities of organizations to work towards strategic innovation by evolving the process to a much higher level; thereby gaining firm's portfolio of difficult-to-trade assets and complementary assets or returns (Teece et al., 1997). In case of healthcare sector the major competitive advantage brought by the hospitals are towards care delivery, patient-centric responsiveness, agility, and higher quality of care (Bradley et al., 2012). The patient-care dynamic capabilities considered in this study are: *Treatment-quality; Treatment-agility & Treatment-responsiveness*.

### ***Treatment-Quality***

Quality is an important factor which provides competitive edge for hospitals in terms of treatment delivered to the patients. Treatment-quality is referred to as the extent to which hospitals can provide effective and efficient treatment which can make the patients satisfied or delighted (Mosadeghrad, 2013). Treatment quality can be a key differentiator to hospital performance when hospitals can reduce medication errors/ risks, provide accurate treatment and adhere to standards and provide value-based care (Gemmel, 2017). In a critical sector like healthcare, it become essential for hospitals to keep treatment-quality to be their primary focus as patients cannot compromise on that keeping their lives at stake. Mulder and Sunderji (2019) emphasized the importance of striking a balance between technical aspects of treatment delivery and measures of patient experiences which is important for patients, providers and the healthcare system in order to offer better quality. Hospital's work environment, coordination within the departments and maintaining safety aspects in treatment are vital factors for delivering better quality-care (Hignett et al., 2018). Treatment-Quality has been attributed to real-time information provision, waiting times, focus on quality assessments, feedbacks, adherence to medical advice, complaints, and grievances which can thereby generate value-based care and are powerful drivers to stakeholders in the health sector (Duku et al., 2018).

### ***Treatment Agility***

Agility is referred to as the firms' ability to respond to the needs of the environment and quickly react to variety of situations (Chakraborty et al., 2019). Agility is indicative of volatile, dynamic and constantly changing needs of services. An agile system needs to be flexible in nature, provide quick response quickly to customer demand and market fluctuations, and optimize costs and quality by adopting upgraded tools, processes, and trainings (Sindhwani et al., 2019). Healthcare has become highly complex and dynamic over the years and hospitals need to focus strongly on care-flexibility and agility (Pipe et al., 2012). Due to the uncertainties of healthcare as it always remains largely unpredictable, it is crucial for hospitals to strive for agility which can emerge as a major competitive factor (Yarrow et al., 2003). Delivering timely treatment is largely important as delays may lead to loss of lives; thus, primary needs of hospitals or healthcare providers are not only to ensure quality treatment but also flexible and agile treatment (Chakraborty and Mandal, 2019). Hospitals catalyze agile applications to improve the services-level and competitive advantage as they need to conform towards rapidly fluctuating patient needs and competitor feedback; thereby focusing on Treatment-agility (Sindhwani et al., 2019).

### ***Treatment Responsiveness***

Responsiveness has been acknowledged as an important factor to achieve competitive edge in service industry. In case of healthcare the service requirements being complex and critical need special focus on treatment responsiveness (Karami-Tanha et al., 2014). Mohammed et al. (2013) highlighted the attributes of responsiveness in healthcare services to be multidimensional which includes prompt attention, dignity, communication, autonomy, choice of provider, quality of facilities, confidentiality and access to family support. Treatment-responsiveness indicates the non-clinical aspects of the health system where hospitals need to provide more attention towards patients' rights and choice and prompt attention towards treatment and care (Karami-Tanha et al., 2014). Provider responsiveness, friendliness and attentiveness have been highlighted as critical components of healthcare service as it helps the hospitals to form a competitive advantage for them (El-Saghier and Nathan, 2013).

## **RESEARCH METHODOLOGY**

This section throws light on the research methodology applied in this study. This section discusses the details of research hypotheses development, construct definitions, empirical analysis section which includes survey instrument development, sampling, data collection and analysis and further discusses the study findings, results and discussions.

### ***Research Hypotheses***

#### ***Linking EMR-Implementation, ERP-Implementation, IoT-Wearables-Usage with Process-Integration***

Digital technology usage like EMR, ERP and IoT-devices have largely transformed the healthcare sector by enabling digitization of the medical-records, fostering real-time information sharing, enabling connectivity and integration of the processes, promoting mobility in health services by enabling virtual medical support by wearables usage and also making the entire process to be interoperable and integrated (Fiaz et al., 2018; Chakravorty et al., 2019). This electronic transformation is drastically making the process much more integrated by avoiding human-errors, communication gap, and coordination loss (Afshan and Sindhuja, 2015). EMR enables the integration of the patient medical records across internal and external departments leading to dramatic change in personalized and agile care delivery (Heart et al., 2017). Platform connectivity by ERP fosters seamless real-time information flow across hospital departments and hospital transaction partners

(i.e. suppliers), thus fostering both intra and inter departments level integration by bridging the gaps among the stakeholders, enhancing interdepartmental communications, improved visibility, transparency and flexibility in the systems. An integrative system enhances faster response in order dispatch, reduce response delays and backlogs; thereby intra-departmental and supplier-focused ERP implementation favors responsiveness of the hospital procurement team and the supplier side order-fulfillment process team and the entire system at large (Garefalkis et al., 2016). IoT-enabled medical devices provides a paradigm of new capabilities, integration and connectivity where technology connectivity and computing capability expand to objects, sensors and items that exchange data with minimal human involvement (Metcalf et al., 2016).

EMR-Implementation in hospitals have been the backbone for new technologies and big-data analytics by enabling the collection of information on advanced health outcomes, risk factors, real-time behavior monitors and patient disease symptoms; thereby integrating the process by aggregating these data in a rapid and cost-effective manner (Wang et al., 2018). EMRs integrated with ERP platforms provide insights for electronic health and remote medical diagnosis (Chakravorty et al., 2019). ERP platform integration fosters medical data coordination with other data sources, including outcome registries, imaging, wearables and research measurements which potentially offers higher-resolution data analytics (Gosink et al., 2019).

Thus, from the above details, it can be hypothesized that:

*H1: Level of EMR-Implementation is positively related with the level of ERP-Implementation in hospitals.*

*H2: Level of EMR-Implementation is positively related with the level of Process-Integration in hospitals.*

*H3: Level of ERP-Implementation is positively related with the level of IoT-Wearables-Usage in hospitals.*

*H4: Level of ERP-Implementation is positively related with the level of Process-Integration in hospitals.*

*H5: Level of IoT-Wearables-Usage is positively related with the level of Process-Integration in hospitals.*

*Linkages of Process-Integration with Treatment-quality, Treatment-agility & Treatment-responsiveness*

Integration enhanced by the technology adoptions like EMR, ERP and IoT devices have largely influenced the treatment transformation in terms of better quality-care, personalized care, treatment agility and responsive care delivery (Heart et al., 2017; Farahani et al., 2018; Fiaz et al., 2018). Andaleeb (2001) suggested that dimensions like quality, responsiveness, assurance, communication and discipline have strong association with patient satisfaction. Integration of medical systems using digital technologies combine demographic, lifestyle and behavioral data with medical records, in order to provide a comprehensive view that coincides and collaborates with patient-centered treatment process. This integration can lead to a dramatic improvement of treatment quality with agile and responsive personalized care resulting in improved health and wellness (Heart et al., 2017). The technology adoptions by hospitals strongly integrate the departments and enables real-time information sharing which reduces various errors caused due to lack of coordination. This integration enhances the treatment quality provided to the patient as can avoid repetition of diagnosis, treatment delays even foster mobility in treatment delivery (Chakravorty et al., 2019). Treatment agility in health care offers process improvement and enhances efficiency by accomplishing systems approach enforced together with proper orientation (Sindhwani et al., 2019). Hospitals compete on agility, flexibility and responsiveness front, in differentiating their own care service delivery propositions from their competitors (Chakraborty and Mandal, 2019). The integration, mobility and interoperability enhanced by digital transformation of healthcare have the ability to enhance attentive and responsive care (El-Saghier and Nathan, 2013).

Thus, from the above details, it can be hypothesized that:

*H6: Level of Process-Integration is positively related with the Treatment-Quality of hospitals.*

*H7: Level of Process-Integration is positively related with the Treatment-Agility of hospitals.*

*H8: Level of Process-Integration is positively related with the Treatment-Responsiveness of hospitals.*

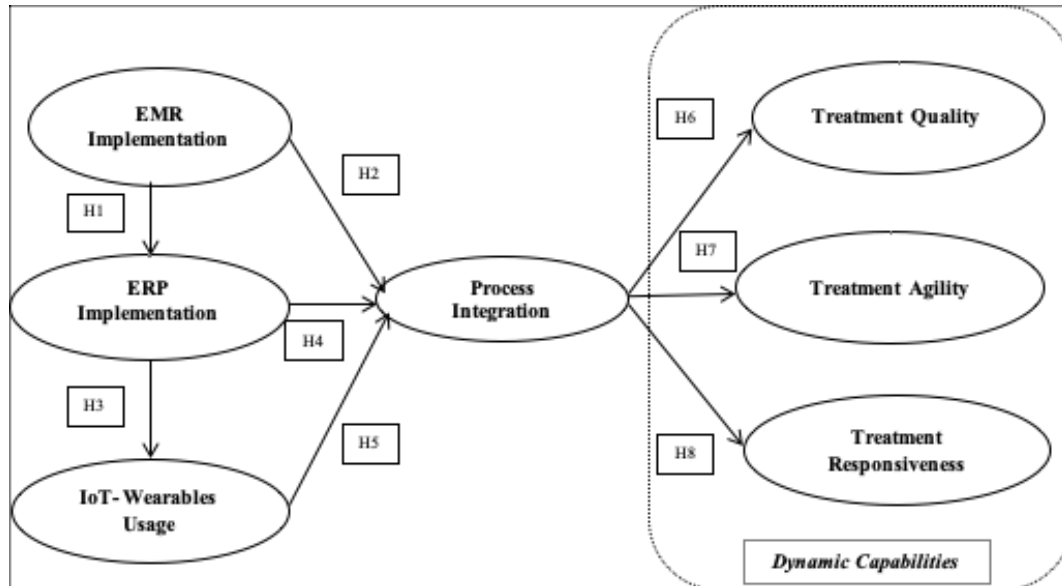


Figure 1. Study Model

As illustrated in Figure 1, the study model analyses the impact of Digital technologies (EMR, ERP & IoT-Wearables) on Process-Integration and also their impact on each other. Further this study also analyses the impact of process-integration with the dynamic capabilities considered in this study that are treatment-quality, treatment-agility and treatment-responsiveness.

Table 1 discusses the definitions of the constructs and measurement questionnaire items of the constructs of this study:

Table-1: Summary of Constructs and respective questionnaire items

Construct Name	Construct Definition	Measurement Items	Reference
EMR-Implementation (EMRI)	EMR-Implementation is the extent to which hospitals have implemented electronic technologies to handle patient medical data.	<ul style="list-style-type: none"> <li>• Documentation of patients’ medical records in digital/electronic format</li> <li>• Conversion the past medical records to electronic platforms</li> <li>• Using EMR to view patient diagnostic reports</li> <li>• Enablement of prescriptions, registrations and records electronically</li> </ul>	Dobrzykowski and Tarafdar, 2017 ; Jha et al., 2009

ERP-Implementation (ERPI)	ERP-Implementation is the extent to which hospitals have implemented ERP-system modules, in their business processes.	<ul style="list-style-type: none"> <li>• Enablement of real-time information sharing across platforms</li> <li>• Provision of more integrated, timely, accurate and reliable information</li> <li>• Integration of information flows and business process across silos</li> <li>• Automation of the business process and platforms</li> </ul>	HassabElnaby et al., 2012; Garefalakis et al., 2016; Fiaz et al., 2018
IoT-Wearables Usage (IOTW)	IoT-Wearable-Usage is the extent to which hospitals are using medical wearables for synchronous health reporting, measuring medical symptoms and real-time patient monitoring.	<ul style="list-style-type: none"> <li>• Mobility of patient medical care</li> <li>• Enablement of regulatory medical devices for flexible care</li> <li>• Connected and synchronous medical reporting</li> <li>• Patient-monitoring even from virtual location</li> </ul>	Farahani et al., 2018; Gosink et al., 2019; Chakravorty et al., 2019
Process Integration (PRIN)	Process-Integration is the extent to which hospitals can coordinate real-time flow of information, material and finances at an intra and inter-level for integrating and standardizing the business process.	<ul style="list-style-type: none"> <li>• Integration of intra and inter level processes</li> <li>• Enablement of the system into a seamless and transparent process</li> <li>• Coordination of real-time flow of information</li> <li>• Standardization of business processes</li> </ul>	Rai et al., 2006; Bradley et al., 2012; Afshan and Sindhuja, 2015
Treatment - Quality (TRQL)	Treatment-Quality is the extent to which hospitals can deliver effective and efficient treatment according to the benchmarked standards to bring customer satisfaction or delight.	<ul style="list-style-type: none"> <li>• Providing competitive edge based on quality.</li> <li>• Providing effective/ efficient treatment thereby making the patients satisfied/ delighted</li> <li>• Adhering to the standards and providing value-based treatment</li> <li>• Enhancing the reliability of the patient treatment services</li> </ul>	Mosadeghrad, 2013; Mulder and Sunderji, 2019



Treatment - Agility (TRAG)	Treatment-Agility is the extent to which hospitals can respond to volatile, dynamic and constantly changing needs of patient services and deliver flexible and timely treatment.	<ul style="list-style-type: none"> <li>• Ability to execute the treatment services in a quicker pace</li> <li>• Ability to respond to variety of treatment needs</li> <li>• Providing volatile, dynamic and constantly changing treatment needs</li> <li>• Accommodating rapidly fluctuating patient needs and competitor feedback</li> </ul>	Sidhwani et al., 2019; Chakraborty and Mandal, 2019
Treatment Responsive ness (TRRS)	Treatment-Responsiveness is the extent to which hospitals can provide friendly, prompt, attentive and on-time treatment to patients.	<ul style="list-style-type: none"> <li>• Providing prompt attention to treatment needs</li> <li>• Operating processes are friendly and attentive</li> <li>• Providing option of shifts convenient to patients.</li> <li>• Customized treatment catering niche patient-needs.</li> </ul>	El-Saghier and Nathan, 2013; Mohammed et al., 2013; Karami-Tanha et al., 2014

### ***Empirical Analysis***

The empirical quantitative analysis approach is used in this study to analyze the concepts in the Indian-healthcare approach. The analysis starts with focused group discussion (FGD) towards development of survey instrument, followed by stratified random sampling, data collection for large scale study, followed by analysis using exploratory factor analysis (EFA), confirmatory factor analysis (CFA) & Structural equation modeling (SEM).

### ***Survey Instrument Development***

Survey-based data collection technique is used for capturing the perception of target sample using well-constructed survey-questionnaire. Questionnaires are question-based instrument for data- collection by putting questions to the respondents which was developed on the basis of extant literature and expert views. The construct items were adapted from extant literature from healthcare or other sectors with proper adaptation to this study context (Items given in Table-1). Six experts, four hospital senior-executives/ superintendents of tertiary-care private hospitals who have experience in EMR, ERP or IoT-wearables usage in hospitals and two academicians of healthcare-operations and hospital-management background are involved for questionnaire validation. This study model comprises of seven constructs with 28 items finalized for questionnaire survey. The responses were taken on seven-point Likert-Scale in which 1= strongly disagree & 7= strongly agree.

### *Sampling and Data collection*

This work is based on empirical investigation in Indian hospital context and data is obtained from tertiary-care private hospitals having digital (EMR, ERP or IoT) practices targeting four major metro cities to achieve a uniform perception and further segregated based on three specialty strata (segment), namely single-specialty, multi-specialty and general hospitals. The hospital samples were identified conveniently, thus following ‘Stratified convenient sampling’. The considered sample list was 698 out of which final 154 proper responses were obtained, thus giving 22.06% response rate which was within acceptable range (Hair et al., 2006).

*The table-2 illustrates the strata-wise collected sample demographics.*

**Table-2: City-wise and Hospital Specialty-wise sample demographics**

<b>SAMPLE AREAS</b>	<b>SINGLE SPECIALTY</b>	<b>MULTI-SPECIALTY</b>	<b>GENERAL HOSPITAL</b>	<b>CITY-WISE TOTAL</b>
<b>NORTHERN-INDIA (Delhi, NCR)</b>	11	25	18	54
<b>SOUTHERN-INDIA (Chennai, Vellore, Suburbs)</b>	12	15	08	35
<b>EASTERN-INDIA (Kolkata, Howrah, 24-Parganas)</b>	14	14	08	36
<b>WESTERN-INDIA (Mumbai, Suburbs)</b>	10	11	08	29
<b>SUB-TOTAL SPECIALTY-WISE</b>	47	65	42	
			<b>TOTAL</b>	<b>154</b>

The response of hospital data was obtained from various hospital stakeholders like hospital managers, senior executives, operations managers, procurement managers, physicians, senior nursing staffs and hospital-superintendents. The responses were taken only from those hospital members who had implemented EMR, ERP or IoT i.e. the technologies considered in this study in some form or the other so that they can analyze the impact of implementation of the respective technologies. All the respondents were asked for their eligibility and consent for response. The demographics of the respondents of sample obtained from hospitals are given below in *Table-3*.

**Table-3: Respondent's Profile-wise sample demographics**

<b>Sample characteristics based on Respondent's profile</b>	
<b>Job title</b>	<b>Respondents</b>
Hospital Managers	14
Senior Executives	18
Hospital Operations Managers	25
Hospital Procurement Managers	16
Physicians	32
Senior nursing staffs	37
Hospital Superintendents	12
	<b>Total-154</b>

**Data Analysis using EFA & CFA**

The quantitative analysis of construct involves the analysis of impact of EMR-Implementation, ERP-Implementation & IoT-Wearables Usage on process-integration and the dynamic capabilities considered here which are treatment-quality, treatment-agility and treatment-responsiveness. The analysis method used is *Exploratory Factor Analysis (EFA) & Confirmatory Factor Analysis (CFA)*.

EFA was carried out in order to ensure the factor structure and uni-dimensionality of the constructs by measures of Item loadings. The convergent validity and reliability measures are obtained by average variance extracted (AVE) values and Cronbach's Alpha respectively. *Table 4 and 5 represents the item loadings, AVE (Average variance extracted) values and Cronbach's alpha values.* Further, CFA was carried out to check the model-fit indices ensuring convergent validity and discriminant validity. Table- 6 represents the Composite Reliability (CR) values and Discriminant validity respectively.

**EFA & CFA findings**

EFA was performed using 154 responses (n=154) collected through survey based questionnaire developed through FGD. EFA was done using Principal component analysis with Varimax Rotation. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy came up as 0.805 (which is acceptable) and Bartlett's test of Sphericity

which is very crucial for EFA validation came up as significant. Seven clear factor structures emerged with cumulative total variance explained as 69.6% and no single factor having percentage of variance more than 50% (*as per Harman's Single factor test*) which shows that EFA was valid. Item loadings for all the constructs were checked which came up above 0.5.

Below Table-4 shows the Rotated EFA Component Matrix:

**Table 4: Rotated EFA Component Matrix**

Rotated Component Matrix <sup>a</sup>							
	Component						
	1	2	3	4	5	6	7
EMRI1	.863						
EMRI3	.834						
EMRI2	.827						
EMRI4	.802						
ERPI4		.891					
ERPI1		.837					
ERPI2		.818					
ERPI3		.791					
IOTW1			0.763				
IOTW2			0.692				
IOTW3			0.829				
IOTW4			0.711				
PRIN2				.821			
PRIN3				.727			
PRIN4				.720			
PRIN1				.685			
TRTQ3					.915		
TRTQ1					.902		
TRTQ2					.861		

TRTQ4					.582			
TRTA4						.929		
TRTA1						.868		
TRTA2						.846		
TRTA3						.657		
TRTR2							.918	
TRTR1							.914	
TRTR3							.845	
TRTR4							.824	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.								
a. Rotation converged in 6 iterations.								

CFA findings illustrate that discriminant validity of the construct measure which is AVE computed for each construct and compared with squared inter-construct correlations (*Table-5 shows the values: Diagonal values are AVE, non-diagonal values are squared inter-construct correlations*).

**Table 5: AVE, Composite reliability, and Cronbach's alpha: Measurement Model**

CONSTRUCT	No. Of Items	Composite Reliability	AVE	Cronbach's Alpha
EMRI	4	0.887	0.692	0.87
ERPI	4	0.803	0.700	0.79
IOTW	4	0.845	0.560	0.83
PRIN	4	0.893	0.550	0.88
TRTQ	4	0.794	0.680	0.77
TRTA	4	0.830	0.690	0.81
TRTR	4	0.932	0.768	0.90

All the AVE values emerged as above 0.5 which is prescribed as standard and all Cronbach's alpha values emerged as above 0.7 and most of them above 0.8 which indicated higher levels of construct reliability. As a secondary measure even composite reliability has been checked for the constructs and all the composite reliability figures are much above the prescribed limit of 0.6 (Table- 5). The diagonal elements in Table 6 represent the AVE values and the non-diagonal element values in the table-6 represents squared inter-construct correlations. Since the diagonal values i.e. the AVE values emerged much higher than the squared

inter-construct correlations, this indicates a very good discriminant validity situation as per the standards.

**Table 6: Discriminant Validity**

Constructs	EMR I	ERPI	IOTW	PRIN	TRTQ	TRTA	TRTR
<b>EMRI</b>	<b>0.692</b>						
<b>ERPI</b>	0.032	<b>0.700</b>					
<b>IOTW</b>	0.017	0.027	<b>0.560</b>				
<b>PRIN</b>	0.001	0.001	0.000	<b>0.550</b>			
<b>TRTQ</b>	0.001	0.042	0.023	0.000	<b>0.680</b>		
<b>TRTA</b>	0.019	0.058	0.008	0.045	0.067	<b>0.690</b>	
<b>TRTR</b>	0.015	0.001	0.028	0.039	0.034	0.044	<b>0.768</b>

#### **Path Analysis using SEM**

Structural Equation Modeling (SEM) has been used to find the interrelationships of the constructs by the measures of Path-coefficients or Model-fit indices. The model-fit indices obtained in this study are CMIN/d.f. = 1.965, GFI = 0.903, RMSEA = 0.05, CFI = 0.92, IFI = 0.93, TLI = 0.904. All the indices were within prescribed limits i.e. CMIN/d.f.  $\leq$  4.000, GFI  $\geq$  0.90, RMSEA  $\leq$  0.050, CFI  $\geq$  0.900, IFI  $\geq$  0.900, TLI  $\geq$  0.900. (Hair et al., 2006)

*Below Table-7 represents the model-fit results.*

**Table 7: Structural model: SEM results for direct effects**

Hypotheses	Relationships	Coefficient	t-value	Remark/status
H1	EMRI→ERPI	0.315	2.915	Supported
H2	EMRI→PRIN	-0.066	0.647	Not Supported
H3	ERPI→IOTW	-0.026	0.543	Not Supported
H4	ERPI→PRIN	0.187	1.572	Supported
H5	IOTW→PRIN	0.396	3.792	Supported
H6	PRIN →TRTQ	0.288	2.654	Supported
H7	PRIN →TRTA	0.423	3.218	Supported
H8	PRIN→TRTR	0.192	1.643	Supported

## DISCUSSION, CONCLUSION AND IMPLICATIONS

In this research work, the impact of implementation of the digital technologies: EMR, ERP and IoT-wearables are analyzed through empirical results in Indian tertiary-care private hospitals. SEM path coefficients are computed and compared to study the details. From the results it was observed that EMR significantly supports the ERP-technologies implementation but does not directly support Process-Integration. This result indicates that electronic management of patients' medical records is incapable of direct integration of processes; rather, EMR combined with ERP-technologies can significantly increase process-integration. ERP can significantly integrate the silos and share real-time information within and across departments in hospitals. Further results highlighted that the relation of ERP with IoT- wearables was also not supported but individually both these two digital technologies (ERP and IoT-Wearables) have a positive impact on Process-Integration. IoT wearables are often used in hospitals to increase mobility and interoperability in the system. Further results have highlighted that the linkages between ERP and IoT-Wearables with process-integration are also significant which shows that ERP and IoT-wearables can effectively increase the integration of the processes in hospital system. Therefore, as conceptualized from theoretical supporting and discussion from cybernetic control theory, it is evident from this empirical study finding that technology implementations can significantly increase the processes, organizational integrations and strategies. Thus, this study contributes to this theory by the empirical validation in Indian hospital context to analyze the consequences of EMR, ERP and IoT-wearables on processes integration.

Further the results have indicated supporting values for linkages of process-integration with all the dynamic capabilities considered in this study i.e. Treatment-quality, treatment-agility and treatment- responsiveness which are positively significant and the hypotheses are supported. Therefore, it can be observed that the theoretical background discussions obtained from dynamic capability theory has been supported in this study in hospital context. Thus, the finding of the paper conforms to the afore-described theoretical premises.

Thus, this study highlights that, electronically managing the medical records i.e. EMR- Implementation in hospitals are having a positive impact on the other technology as well and extends support towards the other technologies as well. Specifically it can be observed that process-integration is a vital aspect of hospital processes and these digital technologies although EMR combined with ERP fosters the integration process. Major highlight of this work is that the dynamic capabilities

(Treatment-quality, agility and responsiveness), which is of primary focus for any hospital in order to achieve competitive-edge in today's highly competitive value focused healthcare sector are all supported with the implementation of the digital technologies. With process-integration as the intermediate step and downstream fostering dynamic-capabilities by digital-technologies, it needs to be emphasized that both intra and inter department integration is needed by technology integration for achieving a better dynamic capability in the healthcare sector. Thus, this study highlights a better understanding of three specific digital technologies implemented together and their impact in the hospitals towards integration and dynamic capabilities.

### ***Implications of the Study***

The current study provides a detailed understanding of healthcare sector and focuses on the digitalization and technology adoption aspects of hospitals. The study provides a combined aspect of three technologies which are EMR, ERP and IoT-wearables or devices implementations which can potentially enlighten hospital managers, physicians and staffs for understanding the impact of the technology implementations towards their processes and treatment capabilities. As this is an empirical study taken from Indian context, it can also motivate the non-digitalized hospitals and healthcare centers to gain knowledge and insight for adoption of these newer technologies. As India is at a nascent stage of digitalization, this study will provide a framework for implications of technology implementations for healthcare managers and further provide motivation for technology adoption.

### ***Limitations and Future scope***

Although the study has attempted to exhaustively capture the understandings and relationships of technology adoptions, and its consequences in healthcare sector, however is not free from limitations. The empirical data obtained is cross-sectional and thus fails to capture any learning curve impact. India being at a nascent stage of technology adoptions in healthcare sector might be an extended study of longitudinal nature can be undertaken for future exploration including aspects of m-health and tele-health. The data is collected from hospitals and physicians perspective, the study can also be extended for patient-side and supplier-side perspective as well.

Future research extensions of this work can be made along the lines of empirically analyzing digital technologies implementations across specializations and nature of hospitals through more detailed focused specialty-based studies and also can be broadened towards public-sector hospitals.



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