Building an ‘Industrial Engineering Mindset’ among Indian Healthcare Executives: Toward Management of Healthcare Facilities at an Industrial Scale post the COVID-19 Pandemic

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Abstract
The COVID-19 pandemic highlighted the necessity of good quality and adequate quantity of healthcare infrastructure facilities. Healthcare facilities were provided for COVID-19 facilities with improvisation and supplementary lateral infrastructure from other sectors. However, the main point of contemplation going into the future was regarding how to quickly develop healthcare facilities. The subject domain of ‘industrial engineering’ (IE) and its associated perspectives could provide some key insights regarding this. The authors undertook a conceptual literature review and provided theoretical argumentation toward this. The findings provided insights regarding the application of industrial engineering concepts in healthcare facilities and services.

Keywords
Industrial engineering perspectives, Indian healthcare sector, managerial mindset, conceptual literature review, argumentation

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Introduction

India as a country has prospered well post the era of liberalization, globalization, and privatization (LPG) embarked from the year 1991 (Agarwal, 2003; Anand, 2014; McCartney, 2009; Sharma, 2015). The footprints of both foreign and private players increased in both Indian industries and the market. Certain sectors in Indian industries, like information technology, aviation, banking, electronics, and telecommunications, among others, did relatively well as compared to certain other sectors. The healthcare industry in India did witness more progress in the late 1990s and the two decades of the new millennium than what India had witnessed in the first half a century post independence. However, most healthcare experts would agree that Indian healthcare facilities infrastructure in terms of both quantity and quality generally had been far weaker than it ought to have been (Golechha, 2015). The quantum of healthcare facilities always was far less than what was required by the country of 1.3 billion citizens (Gupta et al., 2015; Itumalla & Acharyulu, 2012). It would be also important to note that around 30%–40% of the Indian population lived their lives based upon daily/weekly wages of less than US$4–5 a day. Thus, the ability of these individuals to pay for healthcare services and products was extremely limited.

It has been argued that the Indian economy had done well since the year 1991 because of the efforts of Indian workers (the labor force), especially the contract employees (Kotwal et al., 2011; Maiti, 2013). A substantive section of the Indian workforce had over the years put in long, hard hours of work to propel and script the Indian economic boom (Thomas, 2013). However, long hours of work and difficulties of commute had systematically taken a toll on the health of many Indians, especially the ones dwelling in urban areas (Tomozawa, 2017). Given the hardships of work, sedentary lifestyle, intense work pressure, and long hours and difficulties of commuting, many in India suffered from lifestyle diseases (Kaveeshwar & Cornwall, 2014; Misra et al., 2001; Ramachandran, 2004). These individuals mostly belonged to the middle-age group (mid 30s to early 40s) and harbored lifestyle diseases, like diabetes, hypertension, chronic anxiety, and such others (Mohan et al., 2001; Narendran et al., 2002; Unnikrishnan et al., 2007). Over the last few decades, India has become home to one of the largest populations of diabetic and hypertension patients (Mohan et al., 2001; Unnikrishnan et al., 2007). In the long run, people with diabetes, hypertension, and such other diseases often become patients of more severe life-threatening diseases, like chronic renal disease (CRD), cardiac arrests, and others. Given the pressures of work and life in India, reducing the intensity and incidences of diabetes, blood pressure, and other lifestyle diseases would be challenging. One way to address the challenge would be to manage the healthcare system better (Nair, 2015). For an emerging economy like India, the field of ‘industrial engineering’ (IE) might offer a much-needed solution. It would be important to note that though in the context of the manufacturing sector, IE has been a dominant perspective, its uptake in the services sector has been significantly slow. This has been especially so in the context of the healthcare sector. This was surprising, because healthcare has been one of the most critical sectors in services and indeed a sector of prime importance.
for India as a country. Given this context, it would be important that a conceptual review of IE concepts is undertaken and the IE concepts are reviewed anchored to the needs and requirements of the healthcare industry. This could be for hospital owners and managers as the point of reference. Healthcare firm managers and entrepreneurs would require an integrated perspective (Bhattacharyya, 2020). Healthcare firm managers, like any other firm managers, need to capture value (Bhattacharyya & Sivanand, 2011). The authors of this study undertook a conceptual literature review for comprehending the applicability of IE concepts in healthcare services. The article has been organized with the literature review of IE concepts and its applicability in the context of Indian healthcare facilities and its services being discussed in the next section. Subsequently, the decision and the conclusion sections are presented. Toward the end of the article, the managerial-direction implications, the scope of the article and the future directions of research in this domain are presented.

**Study Context of Industrial Engineering in Healthcare**

The field of IE and subsequently its applications in ‘industrial management’ (IM) primarily focused toward increasing productivity (Maynard, 1963). In simple terms, it meant more output per unit input provided (Ritti, 1971). This was achieved through a variety of tools and techniques developed over the years spanning the entire globe. The essence of IM or IE tools was that they did not force the requirement of additional investments in capacity. Instead, generally, IE and IM concepts stressed how to best utilize the invested capacity (Monden, 1981). The principles of IE and IM both pointed toward increasing efficiency and effectiveness. Given a set of constraints of resources and capabilities, ‘maximization’ of certain goals, ‘optimization’ of another set of goals, and ‘minimization’ of the non-value-adding (NVA) activities were stressed (Badiru & Omitaomu, 2010; Maynard, 1963). The means and methods of undertaking the same would focus on achieving output that was of the desired quality, higher output at minimal costs, and timely delivery (Badiru & Omitaomu, 2010; Maynard, 1963). Broadly, IE and IM tools also focused on the activity level. The aim was on reduction of wastes in the necessary activities, as well as on doing away with unnecessary activities for good (Monden, 1981; Ritti, 1971).

As mentioned, the diseases like CRD, cardiac issues, and others would continue to be major segments of diseases in India. From a social perspective, this would require special healthcare for the suffering patients. Given the nature of the socio-economic reality in India, the required healthcare facilities would be required at very affordable rates for a substantive majority of the patients (Nair, 2015). However, from a business perspective, this market, though substantive, would require a fine balance in providing necessary quality healthcare at minimal price points. This would be challenging for organizations providing the same.

However, one must note that in India, healthcare has been an island of excellence in an ocean of needs. Narayana Health (NH) and Aravind Eye Hospitals (AEH) have been lauded all over the globe for providing high-quality cardiac and
ophthalmological health interventional treatments at minimal price points (Ahmed et al., 2017; Chaudhary et al., 2012; Govindarajan & Ramamurti, 2013; Natchiar et al., 2008). NH and AEH provided the best class of healthcare treatment to a substantial number of economically needy patients. In addition to this, there were many hospitals that provided Western (developed-country) standards of healthcare in cardiac, dental, and surgical care, and such others at a fraction of the price point charged by the developed Western countries’ healthcare organizations (Mishra & Shailesh, 2012). Given this, in many cases, patients from the developed world had been coming to India to undergo healthcare services. This indicated that certain Indian healthcare organizations possessed the resources and capabilities to deliver routine tertiary healthcare (super specialty care) at the world’s best quality level (Govindarajan & Ramamurti, 2013). In other words, in terms of resources, as well as capabilities, India possessed excellence in certain hospitals up to the level of best of world standards. The challenge would be to convert such islands of excellence into oceans of excellence. It would be pertinent to note that India has also been a major hub in the global pharmaceutical map primarily in generics (Chittoor et al., 2009; Feinberg & Majumdar, 2001; Kale & Little, 2007). Pharmaceutical capabilities were lateral to the medical capabilities in the healthcare ecosystem (Sultanow et al., 2018). Lenin had famously told that sometimes in decades nothing happens and at other times decades happen in days. The present coronavirus disease 2019 (COVID-19) crisis has been such an event in the world. This event has been potent enough make everyone think regarding the true need of industrial-scale healthcare management facilities. Healthcare provision, like factory-level manufacturing (Narayanamurthy et al., 2018) and the benefits of this, results in productivity improvement, waste reduction, quality improvement, cost reduction, activity-time requirement, and timely delivery.

Research Design for Literature Review

For the conceptual literature review research, the method advocated by scholars was followed (Bhattacharyya & Verma, 2019, 2020; Modgil et al., 2020; Osterrieder et al., 2020; Taylor et al., 2020). The planning of the review was set for IE concepts that were well accepted in reputed journals in IE, like Web of Science- or Scopus-indexed ones. Popular books in IE were also considered for the literature review. For piloting the review, the IE concepts were vetted by two IE experts, one an academic expert and the other a practitioner of IE. The reporting of the conceptual literature review was carried out in a tubular format as advocated by scholars (Osterrieder et al., 2020; Taylor et al., 2020).

In Table 1, the various IE tools that could be applied for management of healthcare in India at the industrial scale are tabulated. In Table 1, the most appropriate IE tool for each concept is presented, with green indicating the most appropriate context, orange moderate usage suitability, and red usage unsuitability. The color coding scheme in Table 1 is based on the authors’ comprehension and analysis regarding the importance and appropriate applicability of the specific IE
concepts in the context of a healthcare facility or a service. Thus, this color coding reflects the intensity analysis of the relevance and fit of the various IE concepts for application in healthcare operations as per the authors’ domain knowledge and expertise. There are three categories of intensity, namely, ‘high intensity and relevance’, ‘moderate intensity and relevance’, and ‘low intensity and relevance’. Green color reflects ‘high intensity and relevance’, yellow color indicates ‘moderate intensity and relevance’, and red color indicates ‘low intensity and relevance’ according to the authors’ analysis.

The literature review of IE concepts presented in Table 1 was set with the objective of developing a comprehension of application of the IE perspective in healthcare management. The main focus was toward such a ‘mindset’ among healthcare managers in India. Owners, administrators, medical/hospital entrepreneurs, doctors, and all other relevant stakeholders responsible for the management of public or private healthcare management facilities and assets need to develop this IE-based ‘mindset’. The importance of ‘mindset’ has been stressed in the management literature (Dweck, 2008, 2015). An IE-laden ‘mindset’, if present across the entire management, staff, and workers in a healthcare facility firm, would usher in a changed frame of references on how healthcare services are delivered. Especially, an IE-driven ‘mindset’ at the leadership level in a healthcare firm can be tautologically argued to develop a positive organizational cultural toward increasing efficiency, as well as efficacy.

**Discussion**

This IE conceptual literature review, set from the perspective of healthcare facilities and services, provides a top-management perspective regarding what concepts of IE should be applied in which healthcare operations, when, and how for the most optimal output. The doctors and nurses, who are the human resources of the healthcare services narrative, have to get on board regarding what IE tools are applied in service delivery in the healthcare facility where they work. They have to be mindful of the objective and boundary condition rules of the implemented IE concepts. Understanding and open communication between doctors and nurses with the healthcare managers would improve the potency of the IE concepts in practice. The essential elements of IE entail that there would be reduction of wastages. This reduction of wastages must occur in the operations activities undertaken during the healthcare services delivery. Wastages must be less regarding all the various resources, namely, manpower, materials, and facilities. This could be well practiced if the methods of Kanban and Kanban pull system are followed as advocated by scholars (Deleersnyder et al., 1989; Krajewski et al., 1987; Ohno, 1982). Even the Gemba Walk as advocated by Rubin and Stone (2010) could be applied to eliminate wastes. Increasingly, digital wisdom is required among managers (Nayak & Bhattacharyya, 2019). Business leaders’ inclination toward technology usage has become pivotal in the present-day context (Jha & Bhattacharyya, 2020), and this applies even for the
| S. No. | Concept                        | Explanation                                                                                      | Applications in Hospitals and Associated Value Chains |
|-------|-------------------------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| 1     | Value stream mapping (VSM)    | VSM aids visualize information and material flows, along with important intermittent steps necessary to deliver a product or service. It helps identify the non-value-adding (NVA) activities and eliminate the wastes (Lasa et al., 2008; Serrano et al., 2008; Hines, 1997). | Application: Productivity Improvement; Waste Reduction; Quality Improvement; Cost Reduction; Activity time Requirement; Timely Delivery |
| 2     | Control charts                | Control charts are used to determine if the behavior of the concerned process is under statistical quality control (Rocke, 1989; Shewhart, 1926). | Application: Productivity Improvement; Waste Reduction; Quality Improvement; Cost Reduction; Activity time Requirement; Timely Delivery |

*Table 1 continued*
| S. No. | Concept | Explanation | Applications in Hospitals and Associated Value Chains |
|--------|---------|-------------|-----------------------------------------------------|
| 3      | Mudas   | Mudas are the wasteful NVA activities (Fercoq et al., 2016; Naylor et al., 1999; Ohno 1988). | Mudas could be applied in various functions: 1. Transport—the unnecessary movement of medical materials, medical professionals, or even patients between various rooms in the hospital; 2. Inventory—nonoptimal levels of required medical equipment or medicines; 3. Motion—excess movement of the staff for performing a task that can otherwise be performed with less movement; 4. Waiting—waiting time of OPD (outpatient department) patient in queue; 5. Overproduction—having excess staff even during lean-demand periods; 6. Overprocessing—repetitive paperwork and manual documentation formalities while admitting the patient; and 7. Defects—failed surgeries due to medical negligence, prescription of wrong medications. |
| S. No. | Concept | Explanation | Applications in Hospitals and Associated Value Chains |
|-------|---------|-------------|-----------------------------------------------------|
| 4     | Muri    | Muri is the overburdening of the system/resources due to unbalanced work/task distribution (Pielęgowski, 2014; Ohno, 1988). | The incoming patient flow peaks during certain times of certain days. The management of this extra burden due to unevenness in patient flow could be addressed by Muri. |
| 5     | 5S      | 5S refers to the principles of 'sort', 'set in order', 'shine', 'standardize', and 'sustain'. 5S helps maintain a well-organized, clutter-free, safe, and productive work environment (Chapman, 2005; Hirano, 1995; Pranckevicius et al., 2008). | The medical tools used for surgery or other procedures could be arranged properly using 5S principles. |
| 6     | DMAIC   | DMAIC is a systematic, data-driven quality improvement methodology. It consists of the following steps: define, measure, analyze, improve, and control (De Mast & Lokkerbol, 2012; Shankar, 2009). | Implementation of DMAIC could reduce the errors caused due to wrong tests in diagnoses activities in pathology labs. |
| 7     | Jidoka  | Jidoka means autonomination: automation combined with human-like intelligence that can detect problems at a very early stage (Baudin, 2007; Gaiardelli et al., 2019). | If any diagnostics machine (CT [computed tomography] scanner) develops some calibration error, then, if based on Jidoka, the machine would automatically stop. This would prevent faulty measurements/diagnoses. |
| 8     | Heijunka| Heijunka means resource leveling and smoothening of workload distribution (Hüttmeir et al., 2009). | Heijunka aids in proper scheduling of the medical staff to match the incoming patient load as per the demand load schedule time of a day. |
| S. No. | Concept | Explanation | Applications in Hospitals and Associated Value Chains |
|-------|---------|-------------|------------------------------------------------------|
| 9     | Poka-yoke | Poka-yoke is an error proofing technique to prevent the occurrence of errors/defects in the first place (Shahin & Ghase-maghaei, 2010; Shingo, 1986). | It is applied for color-coded medicines/vaccines to avoid administering wrong medicines/vaccines to patients. |
| 10    | Voice of the customer (VoC) | VoC helps understand the customer expectations, capture their feedback, and develop better insights for decision-making in providing patient services (Brown, 1991; Cooper & Dreher, 2010; Griffin & Hauser, 1993). | The hospital can try to provide better services to indoor and outdoor patients by understanding what factors are perceived by customers as paramount for their satisfaction and ease of experience. |
| 11    | Quality function deployment (QFD) | QFD is a structured approach to understand and prioritize the customer expectations and convert them into important technical attributes (Brown, 1991; Cooper & Dreher, 2010). | It would help convert the verbal and often qualitative expectations of patients into quantifiable KPIs (key performance indicators) for the healthcare staff. |
| 12    | Suppliers, inputs, process, outputs, and customers (SIPOC) | SIPOC is a six-sigma tool used to map and identify the suppliers, inputs, process, outputs, and customers involved in every process (Mishra & Sharma, 2014; Yeung, 2009). | The tool can be applied to map the stakeholders involved in the value chain in a healthcare facility. |
| S. No. | Concept | Explanation | Applications in Hospitals and Associated Value Chains |
|-------|---------|-------------|------------------------------------------------------|
| 13    | Layout relationship charts | It is a facility location technique that takes into consideration the interrelationships between various departments (Wiyaratn & Watanapa, 2010). | Layout relationships can be used to plan the location of various departments/wards in a hospital. |
| 14    | Work study | It is a combination of time and motion study to enhance productivity (Gilbreth & Kent, 1911; Kanaway, 1992; Taylor, 2004). | The management can standardize the procedures for frequently performed activities (like routine/standard surgeries or dialysis). These activities can be analyzed by using the techniques of time and motion study. |
| 15    | Cellular manufacturing | Cellular manufacturing is used to streamline manufacturing by facilitating continuous flow in small lots and reduce various types of wastes (Heragu, 1994; Singh, 1993). | It can be applied in hospitals to streamline interventional activities. |
| 16    | Kanban | Kanban is a visual system to manage the workflow (Deleersnyder et al., 1989; Krajewski et al., 1987; Ohno, 1982). | Tracking of the staff deployment across various activity stations in hospitals could be done. |
| 17    | Kanban pull system | A Kanban pull system is based on principles of lean management. It focuses on waste reduction by placing replenishment orders only for what has been consumed based on a Kanban trigger (Deleersnyder et al., 1989; Krajewski et al., 1987; Ohno, 1982). | The medical inventory that is kept in an ICU (intensive care unit) room can be optimized and possibilities of overstocking/stockout can be avoided by using a Kanban pull system for inventory management. |
| S. No. | Concept                          | Explanation                                                                                                                                                                                                 | Applications in Hospitals and Associated Value Chains |
|-------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
|       |                                  |                                                                                                                                             | Productivity Improvement | Waste Reduction | Quality Improvement | Cost Reduction | Activity time Requirement | Timely Delivery |
| 18    | Just in time (JIT)               | It is a philosophy aimed at satisfying customer demand while eliminating wastages. A close coordination is ensured between the stakeholders of the supply chain. Generally, pull-based systems are deployed to meet the demand most efficiently (Aycock, 2003; Monden, 2011). | A close relationship with critical partners for the hospital can be built. For example, there could be certain medicines/items/equipment that are not required by the hospital all the time but required in special circumstances. Having good JIT-based suppliers of such medicines/items/equipment would be a win-win situation for all entities involved. |                                                        |
| 19    | Theory of constraints (TOC)      | TOC is an approach designed to help organizations achieve goals while overcoming constraints hindering their growth. It is designed to help organizations increase throughput while simultaneously reducing inventory and operating expenses (Goldratt, 1990; Rahman, 1998). | A hospital can serve a greater number of patients in a better manner by using principles of TOC. Generally, there are few workstations/activities that are slower than the others. These are the bottleneck resources. By using TOC, the constraints could be exploited to achieve higher throughput, lower work in process inventory (like less patients waiting to receive treatment), and a higher ROI (return on investment). |                                                        |

(Table 1 continued)
| S. No. | Concept          | Explanation                                                                                                                                                                                                 | Applications in Hospitals and Associated Value Chains |
|-------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
|       |                  |                                                                                               | Productivity Improvement | Waste Reduction | Quality Improvement | Cost Reduction | Activity time Requirement | Timely Delivery |
| 20    | Bottleneck       | A bottleneck process is a process that has a lower output capacity rate than the entire system. The overall throughput rate of the system is thus dependent on the bottleneck process (Goldratt, 1990; Rahman, 1998). | Bottleneck resources could be identified as the ones that generally have the highest queue of patients waiting just prior to it. It could be an X-ray station, CT scanning, or even a super specialty doctor. |
| 21    | Drum Buffer Rope | It is a planning and scheduling technique in which the bottleneck process sets the overall pace of the activities. It is based on the thinking that the bottleneck is a critical process and should not remain idle. Buffers are placed before the bottleneck to prevent it from being starved of input resources (Goldratt, 1990; Guide, 1996). | If a super specialty doctor is identified as a bottleneck, then the appointment of patients could be scheduled as per the patient handling rate of the doctor (the bottleneck in this case). There should be few buffer patients waiting so that the doctor’s (who is a critical bottleneck resource) time will not be wasted. The rope signifies that the next lot of patients should be called whenever the number of buffer patients falls to a predetermined level. |
| S. No. | Concept          | Explanation                                                                                                                                                                                                 | Applications in Hospitals and Associated Value Chains |
|-------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| 22    | Kaizen           | Kaizen refers to the Japanese philosophy of continuous improvement (Berger, 1997; Brunet & New, 2003). Through the active involvement of the entire healthcare facility staff, various new ideas of the management could be tried, the motive being to continuously improve the state of affairs of operations at the hospital. |                                                          |
| 23    | Quality circle (QC) | A QC is a group of workers who voluntarily meet regularly to brainstorm and discuss methods to improve the quality, productivity, and efficiency of their work. Various problems faced by the workers are discussed, along with methods to overcome the issues (Lee et al., 2000; Steel et al., 1985). Different function groups in a hospital could be part of a QC to improve the state of affairs of operations at the hospital. |                                                          |
| 24    | Gantt chart      | Gantt charts are visual charts to plan and track the progress of various activities and/or deployment of resources (Al-Araidi et al., 2010; Gantt, 1919; Maylor, 2001). Gantt charts could be applied to undertake high-value healthcare interventional activities properly and in time. |                                                          |
| S. No. | Concept | Explanation | Applications in Hospitals and Associated Value Chains |
|-------|---------|-------------|-----------------------------------------------------|
| 25    | Gemba Walk | A Gemba Walk involves a tour of the work floor, observing it to identify improvement opportunities and eliminate wastes (Rubin & Stone, 2010). | In different hospital floors or activities Gemba Walks can help in the identification of improvement areas. |
| 26    | Root cause analysis (RCA) | RCA is a systematic and structured approach for identifying the basic causes for defects and problems (Rooney & Heuvel, 2004; Wu et al., 2008). | The major problems arising in a hospital can be figured out through applying RCA. |
| 27    | Andon | Andon is an audiovisual signal to indicate the current status of a workstation (Eswaramoorthi et al., 2011; Li & Blumenfeld, 2006). | Visual, light-based signals indicating the current state of operations at an emergency response station of a hospital could be monitored. Various symbols can convey different messages, like all okay, urgent assistance of senior doctor required, and such others. |
| 28    | Failure Modes and Effects Analysis (FMEA) | FMEA is used to identify potential modes of failure. It also helps evaluate the relative severity, occurrence, and ease of detection of failure during the design phase of a product/service (Day et al., 2006; DeRosier et al., 2002). | Doctors could identify and classify various potential failures that may occur during a medical intervention. Based on the risk priority, a number of corrective measures can be deployed to prevent such errors from occurring. |
| S. No. | Concept                                      | Explanation                                                                 | Applications in Hospitals and Associated Value Chains | Productivity Improvement | Waste Reduction | Quality Improvement | Cost Reduction | Activity time Requirement | Timely Delivery |
|-------|----------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------|--------------------------|-----------------|---------------------|----------------|---------------------------|----------------|
| 29    | Single-Minute Exchange of Die (SMED)         | SMED is one of the lean manufacturing techniques useful for reducing the setup and changeover times between different processes (McIntosh et al., 2000). | Surgeons could perform multiple surgeries if they do not need to waste their time getting involved in routine setup activities. These could instead be done by medical assistants. The medical assistants could undertake the feasible setup activities that are complementary to the core surgery tasks beforehand. | Yellow Green            | Yellow          | Green               | Yellow         | Green                     | Green          |
| 30    | Continuous review inventory system (CRIS)    | In this inventory management policy, the stock levels are checked and updated as soon as a product leaves or enters the inventory (Axäter, 1993; Kocer & Yalcin, 2020; Moinzadeh & Nahmias, 1988; Moon & Choi, 1998). | CRIS can be recommended for monitoring high-value, critical products in hospitals. For example, extremely costly emergency-room medicines that are only required during specific, not-so-common emergencies could be managed with this inventory policy. | Yellow Green            | Yellow          | Green               | Yellow         | Green                     | Green          |

*Source:* The authors.
context of healthcare executives. In the Indian healthcare sector, given the rapid growth context, human resources management innovations have been viewed as critical (Srinivasan & Chandwani, 2014). Among healthcare professionals in emerging economies too, technology adoption has been stressed, like Web 2.0 adoption (Singh et al., 2018) or mobile technology for even community healthcare services (Fletcher-Brown et al., 2020). This has also been advocated for the services such as health insurance (Nayak et al., 2019a, 2019b). Manpower in this case consists of doctors, nurses, paramedics, and such others. Materials consist of the items such as surgical provisions, hospital items, medical equipment, accessories, and such others. The next benefit would be lower usage of power, water, etc. Further, the benefit of an IE mindset among healthcare executives is that it entails a focus regarding quality. Quality stems from the consistency and precision of healthcare services provision, be it in diagnostics, regular checkup telecare, surgical interventions, or even postoperative care services. This could be best understood from the IE concepts of quality circle (QC) (Lee et al., 2000; Steel et al., 1985) and DMAIC (define, measure, analyze, improve, and control; De Mast & Lokkerbol, 2012; Shankar, 2009). QC, as advocated by Lee et al. (2000) and Steel et al. (1985), could be applied to maintain healthcare services’ quality through the participation of healthcare professionals. DMAIC can be applied in healthcare facilities management and services with a systematic, data-driven quality improvement methodology, following the steps of define, measure, analyze, improve, and control (De Mast et al., 2012; Shankar, 2009). Further, root cause analysis (RCA) could be applied in a systematic and structured way for identifying the basic causes of problems in healthcare services and facilities management, as RCA as a tool has been viewed as very potent (Rooney & Heuvel, 2004; Wu et al., 2008).

Another important element in the application of IE concepts in healthcare stems from the value–cost proposition. In a country like India, healthcare provisions have to be affordable, and toward this, healthcare services have to be provided at the lowest cost. This would entail that minimum inputs are incurred in delivery. Cost consciousness and the sensitivity to reduce costs sprouted from the concepts of economies of scale and scope, but most importantly, from an IE perspective, costs could be reduced with increased efficiency and efficacy of the healthcare services delivery. This is portrayed by the IE-based tools of value stream mapping (VSM; Hines & Rich, 1997; Serrano et al., 2008; Serrano Lasa et al., 2008), Mudas (Fercoq et al., 2016; Naylor et al., 1999; Ohno, 1988), Jidoka (Baudin, 2007; Gaiardelli et al., 2019), and Heijunka (Hüttmeir et al., 2009). Through the application of VSM, Mudas, Jidoka, and Heijunka, NVA activities could be eliminated and buffers and wastages could be reduced, resulting in savings. Another element of IE-based thinking results from the application of temporal thinking built into healthcare service provision. This is depicted in the IE concepts of continuous review inventory system (CRIS) (Axsäter, 1993; Kocer & Yalcin, 2020; Moinzadeh & Nahmias, 1988; Moon & Choi, 1998; Sangeetha et al., 2020) and suppliers, inputs, process, outputs, and customers (SIPOC; Mishra & Sharma, 2014; Yeung, 2009). IE concepts emphasize the need for timely delivery of healthcare services, as well as timely purchase and stocking of the
critical ingredients of medical supplies. Drum Buffer Rope (Goldratt, 1990; Guide, 1996) and the theory of constraints (TOC; Goldratt, 1990; Rahman, 1998) are concepts that, as advocated, could be applied to remove the constraints that delay the delivery of healthcare services. Even in the present-day context, the voice of the customer (VoC), as advocated by scholars (Brown, 1991; Cooper & Dreher, 2010; Griffin & Hauser, 1993), could be applied to understand the patients’ expectations, and their feedback could be considered for securing insights for healthcare services decision-making.

**Conclusion**

This study was a conceptual work. This conceptual literature review would help provide IE scholars, as well as healthcare facilities and their service delivery researchers, a platform to anchor their research to a set of theoretical constructs on IE concepts. Healthcare facility managers and healthcare service executives, in turn, based on this conceptual literature review, could comprehend what kinds of appropriate tools they could apply so as to make the relevant healthcare facilities management and service delivery more efficient and effective and with increased efficacy. Application of the IE concepts outlined in the study would help in providing quality healthcare, at affordable price points, in a timely fashion and in adequate quantity. India, a country with a large population, needs the application of IE concepts both in healthcare facilities management and in healthcare services delivery. This study was a conceptual literature review. In future, empirical studies could be undertaken for investigations regarding the adoption, application, and implementation of these IE concepts in both healthcare facilities management and healthcare services delivery. It would be important to understand that for healthcare firms to succeed, apart from the hard infrastructure, a vigorous soft (IE-motivated ‘mindset’) infrastructure is necessary. Difficulties definitely reside in securing hard assets, like physical infrastructure, healthcare equipment, technology, and others, but it is of paramount importance that an IE-oriented healthcare management ‘mindset’ is developed in parallel, if not first, fast. This would lead to industrial-scale management of healthcare, an existential need indeed for India. At an organizational level, this would result in increased productivity, with the present healthcare facilities’ capacity. Optimized production with the given organizational healthcare resource and capability constraints would be possible as well, as there would be reduced wastages in healthcare value addition processes. Further, elimination of NVA healthcare processes and increased efficiency and effectiveness of healthcare services would be possible. The cost of operations would be reduced, so as to deliver healthcare services at lower price points, and the time to deliver healthcare services would be reduced. Quality delivery of healthcare services over time across different facilities would also be possible. Finally, easy-to-experience healthcare services could be provided to consumers.

The combined effects of these benefits would result in substantive gains (Kondasani & Panda, 2015; Narayananmurthy et al., 2018; Nayak et al., 2018;
Young & McClean, 2009). The aim of the study was to comprehend how an ‘IE’-based ‘mindset’ in healthcare provision could be developed among healthcare managers, hospital owners, administrators, and policymakers in India. First, an ‘intent’ has to be developed among the managers (Reyes-Rodriguez et al., 2013; Wheeler et al., 2010). Subsequent to that, the managerial intent has to be converted into organizational action through consistent behavioral change among the organizational actors (Dutton & Jackson, 1987; Ghoshal & Bartlett, 1994; Nadler & Tushman, 1990; Turner & Rindova, 2012). This was a conceptual treatise; however, future studies would be required to provide a theoretical explication regarding developing a ‘mindset’. Specific contributions would be required toward the ‘process of generation and development’ of ‘mindset’, in this case that of an ‘IE’-based ‘mindset’ in the context of healthcare in India. This would thus help practitioners regarding the necessities for developing more enhanced and better-quality healthcare facilities through developing an appropriate managerial or administrative ‘mindset’. This study’s results shall be helpful for Indian society in general, because improvement of healthcare is a primary social welfare goal of any nation and very much so in the Indian context. Given the troubled times of COVID-19, such studies would provide timely insights regarding better provision of healthcare, which would be a win-win for all stakeholders. Studies on ‘IE’-based ‘mindset’ from a healthcare perspective have been very scarce. Given this backdrop, the authors posit that future studies on how to inculcate an IE-driven ‘mindset’ among healthcare executives in India is of paramount importance, and this conceptual study is the initial step on that path.

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