

# Exploring the use of operational excellence methodologies in the era of COVID-19: perspectives from leading academics and practitioners

Operational  
excellence  
methodologies

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## Abstract

**Purpose** – This paper aims to present the results of a study carried out by the authors in the form of research interviews on the topic: “Exploring the use of operational excellence methodologies in the era of COVID-19.”

**Design/methodology/approach** – A qualitative interview approach was utilized by interviewing a panel of leading academics and practitioners who are familiar with operation excellence methodologies.

**Findings** – Operational excellence methodologies are proven and can be utilized in pandemic situations to improve efficiency in the healthcare system and preparedness for pandemics.

**Research limitations/implications** – One limitation of this research was that most of the interviewees who participated in this study came from Europe, North America, South America and Asia, representing four continents. It would have been better to have different views from other continents such as Australia and Africa. Also, the interviews were short and at a high level. There is an opportunity for further study and analysis.

**Practical implications** – Operational excellence methodologies are proven and can be utilized in pandemic situations to improve efficiency in the healthcare system and preparedness for pandemics.

**Originality/value** – The paper provides an excellent resource for those people to get an insight into the value of the application of operations excellence methodologies in pandemic situations to aid healthcare process improvement and aid public and patient safety.

**Keywords** Operational excellence, Quality, Six Sigma, Lean, Agile, Continuous improvement, Healthcare, Pandemic

**Paper type** Research paper

## Introduction

In times of pandemic and particularly with COVID-19, which is highly contagious via droplets, the healthcare community faces unprecedented challenges. The COVID-19 pandemic has resulted in over 21 million infections and fewer than one million deaths and has spread globally, with over 213 countries affected (the WHO, 2020). The virus is showing no signs of abating pending the development of a vaccine. The challenges facing the public, healthcare professionals and healthcare facilities include trying to rapidly scale-up diagnostic testing and increase laboratory capacity; physically protecting workers with personal protective equipment (PPE) and providing safe working environments including social distancing; managing physical and clinical capacity for care of highly contagious patients, ensuring high inventories of required equipment, ventilators and drugs (Nembrandt *et al.*, 2020).

The stakeholders involved in a public-health crisis requires many inputs, such as hospitals, urgent care centers, community health centers, general practices, long-term care



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facilities, government and local health departments and their workers to organize and work in new ways on almost a daily basis to respond to a growing volume of complex patients amidst staff and supply shortages. While there is no exact prescriptive methodology for dealing with pandemics, existing improvement research as well as evidence during COVID-19 points to ways that organizations such as healthcare and hospitals can manage issues such as those highlighted above around the pandemic through the use of operational excellence methodologies. Operational excellence methods can be utilized to drive improvement and protect patient and public health, ensure their safety and overcome process and clinical challenges.

This research article aims to answer the question, “*How can operational excellence methodology such as Lean Six Sigma (LSS) help in the era of COVID-19?*” There is a dearth of published peer-reviewed journal articles on operational excellence methods and their role in the COVID-19 crisis. However, there has been much commentary by operational excellence experts and practitioners in the media and on LSS websites on how LSS can help during COVID-19 and with other pandemic related illnesses; ([The Future Factory, 2020](#); [Lean Enterprise Unit, 2020](#); [Pzydek Institute, 2020](#); [Six Sigma Global Institute, 2020](#); [Marketplace, 2020](#); [GoLeanSigma, 2020](#)).

In this article, the authors present the findings of our research question on how operational excellence can play a role in protecting the public against COVID-19.

## Literature review

### *Operational excellence methodologies*

Many operational excellence methodologies exist in the literature. The five methods focused on in this article are Six Sigma, lean, LSS, agile and leagile, which all drive continuous improvement. Motorola Inc. coined the term Six Sigma in the mid-1980s as a metric for measuring defects and improving quality. Six Sigma has evolved into a robust business process improvement initiative over the past three decades ([Antony, 2004](#); [Armugam, 2014](#); [Revere et al., 2004](#)). Six Sigma has been widely used in the healthcare sector as a management strategy to improve patient quality and safety as part of their quality management system. ([Trakulsunti et al., 2020](#); [Niñerola et al., 2020](#); [Glasgow et al., 2010](#)).

The Six Sigma methodology utilizes a DMAIC (Define, Measure, Analyse, Improve and Control) approach to tackle problems with unknown solutions, especially when the root causes are to be discovered ([Antony et al., 2018](#)). Six Sigma, as a set of statistical and nonstatistical tools integrated within the DMAIC method, gives a framework for process improvement.

Six Sigma has many proven benefits in healthcare in improving capacity, reducing medication errors, reducing waiting time variation as described by [Tolga Taner et al. \(2007\)](#) in utilizing data collection, pareto analysis, cause and effect and flowcharts to understand healthcare processes, root cause variation and causes of error. Reducing medical errors ([Lanham and Maxson Cooper, 2003](#); [Kumar and Steinebach 2008](#); [Trakulsunti et al., 2020](#)), reducing analytical lab errors ([Riebling, 2005](#)), improving turnaround time ([Sanders and Karr, 2015](#)) and reducing patient waiting time ([Gijo et al., 2013](#)) and maximization of resources are some of the proven benefits of six sigma in healthcare.

Lean was derived from Taiichi Ohno's postwar Japanese Production system, and its benefits are advocated by [Womack and Jones \(1998\)](#) in “Lean Thinking” and in “The Machine that Changed the World” ([Womack and Jones, 1990](#)) has defined lean thinking as “a way to do more with less and less human effort, less equipment, less time and less space while coming closer to providing customers with what they want.” Adding value, creating flow and establishing pull in pursuit of continuous perfection or improvement aligns with the quality management philosophy of continuous improvement and putting the customer first.

The primary goal of lean thinking is to reduce or eliminate waste and waste is anything which adds no value in the eyes of customers. The focus on nonvalue-added waste elimination and the seven wastes of transport, inventory, motion, waiting, overproduction, overprocessing and defects is particularly vital in healthcare where Gowen *et al.* (2012) has estimated nonvalue added is 95% of healthcare operations and leaving room for substantial efficiency improvement (Hagan, 2011). Common lean management tools in healthcare include process mapping, value stream mapping, Kaizen improvement events, just-in-time process management and “5S” principles (Graban, 2017; Protzman, 2017).

Although both Lean and Six Sigma had produced immense and significant benefits to many organizations, they do have some limitations. George (2002) has successfully integrated these two powerful methodologies for business process improvement and claimed that the integrated approach is superior to using Lean or Six Sigma on its own. His view was that Lean is not well suited for resolving complex problems that require intensive data analysis and advanced statistical tools and techniques. Those implementing Six Sigma found that not every problem needed several months of data collection to resolve. Quality professionals found that Lean principles and tools could be primarily applied with minimal data collection and immediate results can be achieved.

Lean is primarily focused on the flow of information and material between the processes. Therefore, if the root cause of the problem is a flow issue, Lean is likely to work well. Deploying Six Sigma in isolation cannot remove all types of waste from the business process and deploying Lean management in isolation cannot bring a process into the state of statistical control and remove variation from the process. LSS is a business process improvement methodology that focuses on process performance, resulting in enhanced customer satisfaction and improved bottom-line results in hard-cash savings. LSS provides the concepts, methods, tools and techniques for process management. It is an effective leadership development tool as it prepares leaders for their role in managing change (Antony *et al.*, 2017).

The combined LSS strategy integrates human aspects (such as leadership, customer focus and cultural change) and process aspects (such as process capability, process management and statistical thinking) for continuous improvement (Bhat *et al.*, 2019; Antony, 2011). Integrating Lean principles of reducing waste with Six sigma’s aim of reducing variation through value stream mapping and analysis and statistical process control can serve to improve patient satisfaction and outcomes.

“Agile governance” is a concept coined in the field of software engineering (Janssen and Voort, 2020) and is an umbrella term for a set of management practices – including SCRUM, kanban and lean – which enable offering requirements and solutions to evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development, early delivery and continuous improvement, and it institutionalizes a rapid and flexible response to customer input (Denning, 2016). The characteristics of agile are robustness, adaptability and responsiveness lend to having an ability to manage service demand fluctuations and variability, changing direction with ease in the event of sudden change and a high-speed response in the event of changing market situations (Olsson and Aronsson, 2015). The need of achieving lean and agile objectives at the same time has led to the emergence of a hybrid strategy known as leagility (Vinaytosh *et al.*, 2019). Lean and agile integrated as leagile can lead to reduced costs and wastes with increased responsiveness and buffer capacity.

### *Operational excellence principles and methods in the era of pandemics*

As outlined in the Introduction, the purpose of this research was to review what lessons can be learned from previous pandemics and outline how continuous improvement

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methodologies can be leveraged and integrated with these lessons learned (LL) from pandemics to ensure process efficiency and patient safety. There are several learnings from pandemics concerning healthcare and hospitals those can be implemented utilizing operational excellence and business process improvement methodologies specifically concerning COVID-19:

#### *The role of Lean Six Sigma*

Choosing the “right” measures of infection levels (the “M” in DMAIC), the measurement of the numbers waiting for testing, numbers positive/negative, number of deaths and infection rates has never been more important. Measuring and defining the problem’s size and defining the “right” problem statement (Pzydek, 2020), management of targets and resources and targeting improvement efforts in the right places have also been important. Some countries have underreported incidences compared to others and have stated there was overreporting. A high test rate gives the public confidence whilst gaining knowledge of the true infection rate; low- intensive care unit occupancy is essential for hospital staff in terms of preparedness for surge capacity levels and important to public-health officials and the public regarding confidence that infection is not spreading. Constantly reviewing operational plans and utilization of command centers (Berkery et al., 2020), data- and statistical-driven reviews with key performance metrics are essential. Keeping variation in performance outputs as low as possible and eliminating root causes for such variation is the key in an integrated approach for mitigating and managing COVID-19.

Variation in measurement has been a problem throughout COVID with respect to variation in test times (Laux et al., 2020), ranging from hours in one country to days in others. LSS is a methodology that can effectively seek out the contributing factors to this variation, help map or measure the components of the testing process from start to finish from a patient value perspective and determine the root causes of such undesirable variation using appropriate tools in the tool box.

Risk management with the use of failure mode effect analysis (FMEA) to identify risks and create contingency plans and training for contingencies has been important in the pandemic, such as ventilator training, ICU training, planning for surges and personal and workplace preparedness for emergency action. Planning for stockpiling inventory such as PPE, ventilators, pharmaceuticals and medical devices, as well as backing up supplies with second source suppliers, is an important part of supply chain planning and maintaining flow in the value stream.

#### *The role of lean and agile*

Managing visually is important so everyone can easily see “out-of-standard” conditions and problems (Lean Sensei Women, 2020). One of the easiest things that people can implement quickly and use easily is simple visual management systems. These systems allow people to see, immediately, when something is not right (Lean Sensei Women, 2020). An obvious example of this during COVID-19 has been signs, posters, floor markers for distancing, combining visual management and 5S approaches. Waste elimination by mapping the value stream and going to the Gemba and utilizing 5S (Ballé, 2020) have a huge role. Identifying waste and nonvalue added touchpoints is helpful in error-proofing processes to prevent infection or minimize contact points. The “Cleaning” step in 5S has become more important than ever, as well as assuring appropriate PPE, disinfectants, checking whether handwash is available, sterilizing and disinfecting of workplaces and equipment. Value stream mapping as well as being utilized to eliminate waste and infection points has been important in designing processes for better flow (Obara, 2020; Martichenko, 2020; Berkery et al., 2020) infection testing, re-layout of wards and waiting rooms though avoiding patients unnecessarily

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introducing themselves to the hospital; testing offsite and utilization of teleconferences where possible. Surge capacity planning (Aruru *et al.*, 2020) and preventative contingency planning by creating flow and space to quarantine and segregate infected patients while keeping others separate; overflow wards; offsite wards; laboratory testing capacity and error proofing are all outputs of using Lean concepts.

SMED or quick changeover is also another Lean concept applicable to COVID; many factories have retrofitted or changed layouts and configurations to enable the production of PPE, ventilators and other types of necessary equipment. Hospitals and testing centers have had to utilize SMED principles to organize for surge and increased volumes. Poke yoke through prevention via vaccination; wearing masks and PPE and social distancing are all error-proof methods. Redesigning door handles and replacing elbow levers or foot pedals, washing hands and encouraging telehealth rather than in-person visits (Berkery, 2020) are all good examples of errorproofing.

Leagile, the integration of Lean and agile methods, can ensure Lean elimination of waste and agile responsiveness. Leagile can be utilized particularly in the supply chain for surge hospital capacity and having buffer stocks to be more responsive in the light of unpredictability in demand during pandemics. Common practices between lean and agile according to Iqbal *et al.* (2020) include strategic vision and planning, information system, cross training, empowered teams and relationships with customers and suppliers.

Healthcare services face a dual challenge of being lean and agile at the same time and both lean and agile have a place in inventory management in healthcare in particular (Vinaytosh *et al.*, 2019). Agile practices can help manage healthcare supply chain sourcing and inventory strategies (Nabelsi and Gagnon (2017) and enable hospital supply chains to be reactive particularly in pandemic times of inventory and equipment scarcity (Lin *et al.*, 2006; Tolf *et al.*, 2015; Christopher and Towill, 2000). An agile approach as described by Olsson and Aronsson (2015) based on accommodation of unpredictable demand including low volumes per individual “product” and high levels of “product” variety can provide the necessary flexibility in healthcare delivery, especially in a dynamic healthcare environment. With an agile strategy, flexible capacities are used to respond to variations (Aronsson *et al.*, 2011) for example proving extra beds, equipment and personnel capacity.

In capacity management, lean tries to stay at a fixed capacity and eliminate nonvalue add and variation while agile aligns to be more flexible robust and responsive in nonnormal times and when faced with external variation (Aronson *et al.*, 2011; Olsson and Aronsson, 2015).

In summary, quality planning, improvement and control aligned with continuous improvement methodologies such as Lean, Six Sigma, LSS, agile and leagile are instrumental in providing solutions and planning for contingencies when global pandemics challenges the health system and public safety.

However, deploying LL from previous pandemics and continuously improving is obvious, saving lives and money and reducing the economy’s impact. The very nature of this global public-health crisis presents process challenges as well as clinical challenges. Together, healthcare staff — from the General Practitioner right through to ICU — can meet some of these challenges by applying the sound and robust principles, tools and methodologies of operational excellence methodologies.

## Methodology

In our attempt to understand the role of operational excellence methodologies such as LSS, it was necessary to conduct exploratory inquiries in the form of a qualitative research approach with interviews. The primary research philosophy of this study is based on an interpretive first understanding of the context – a strategy that meets the need of this research is an exploratory study (Shields and Rangarajan, 2013). The convenience sampling technique was

applied with the focus on gaining in-depth and qualitative insights rather than generalizability (Yin, 2009).

A qualitative research approach with interviews was taken to focus on describing and understanding observations and opinions on the topic from a series of experts. In this research, an expert, as outlined in Figure 1, is a person with at least ten years' experience in the research discipline either through research and publications route or applications in a real-world setting. Qualitatively researching the potential of operation excellence methodology and its associated tools/techniques and applying those in COVID-19 times

Participant Name	Organisation	Years of Experience in Operational Excellence/LSS methodology	Location	Position
Jiju Antony	Heriot-Watt University	25	United Kingdom	Professor
Colin Barr	Colin Barr Associates	40	United Kingdom	Business Process Improvement and LSS Consultant
Richard Keegan	Trinity College, Dublin	40	Ireland	Professor
James Joseph Waskiel	ZFR M&A Engineering Consultancy	40	Denmark	Operational Excellence & LSS Consultant
Ronald Fite	Fites Professional Services	45	USA	Lean Six Sigma Consultant
Marcelo Machado Fernandes	MF Consultants	20	Brazil	Lean Six Sigma Consultant
Bart Lameijer	University of Amsterdam	10	The Netherlands	Lecturer
Dick Keely	Future Perfect Ltd	40	Ireland	Business Process Improvement and LSS Consultant
Sean Moore	University of Limerick	30	Ireland	Senior Lecturer
Sheeranga Bhat	St. Josephs Engineering College	20	India	Professor
Jd Marhevko	BorgWarner Inc.	30	USA	Vice President Quality & Operational Excellence
Ayon Chakraborty	Indian Institute of Management	22	India	Associate Professor
Alessandro Laureani	KBC Bank	21	Ireland	Process Management Leader

**Figure 1.**  
Panel of experts



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was selected as a research approach that will contribute toward understanding the role of operational excellence and opportunities to leverage these methodologies.

The participants' COVID-19 situation and geographical location meant that the nature of the research interviews was adapted to be online. Online group interviews were conducted instead of face-to-face interviews to leverage the benefits of the online medium (Dodds and Hess, 2020). The use of interviews was considered an appropriate methodological vehicle as to the goal of obtaining richness in data through a frank discussion with the interviewees (Palmerino, 1999; O'Donnell and Cummins, 1999; Underwood, 2003). The next step involved the identification of the right candidates for the interviews. The authors sent emails to relevant senior professionals and operational excellence experts from various backgrounds, including academia, industry and consultancy. Interviews were then scheduled with a selection of the respondents and conducted via online platforms.

The details of the project's purpose was clearly explained to all participants when opening the interview and a participant's right to confidentiality, anonymity and the right to avoid answering any question, or stop the interview at any moment, were carefully emphasized (Saunders *et al.*, 2012). In order to minimize bias from the interviewees, the researchers assured the participants of each company that their responses to the questions would be kept confidential, and there were no right or wrong answers to the questions (Polit and Beck, 2004).

The interviews were short and unstructured with one main open-ended question in which the interviewees were asked to answer the main question "How can operational excellence methodologies help in public health and patient safety in the era of COVID-19" and asked various sub-questions around the tools, concepts and practices of different operational excellence methodologies that would be of benefit. An unstructured interview often starts with a broad, open question concerning the area of study, with subsequent questions dependent on the participant's responses (Holloway and Wheeler 2010). The strengths of such interviews are that they do not restrict the questions that can be asked and are useful when little is known about a topic or in collecting background data (Ryan *et al.*, 2009). In this research, very little was known to many participants about COVID-19 and therefore justifies the use of unstructured interviews. Unstructured interviews can be unsuitable for the novice researcher and are prone to researcher bias, which can result in inappropriate questions being asked. To overcome the above issue, the authors have carried out these interviews as both have extensive experience in conducting such interviews.

The interviews were unstructured with the advantage that the respondents could expand, illustrate and digress (Kvale, 1983). The interviews also allow the advantage of narrative inquiry where the authors used a small number of participants to conduct qualitative interviews to gauge their experience, understand or knowledge of the COVID-19 situation concerning public safety (Saunders *et al.*, 2012). After the completion of the fieldwork, all the interviews were transcribed, and common themes were identified.

### **The use of operational excellence methods in the era of COVID-19: key findings from the interviews**

The authors have discussed the value of using operational excellence methodologies such as LSS and agile principles/concepts in the light of LL from previous pandemics and during the COVID-19 pandemic. Improvement methodologies have a place in the integration of LL into current healthcare processes and practices to aid public and patient safety and process improvement efficiencies. The authors have put together a panel of experts in operational excellence and discussed this topic via interviews. The people who have participated in these interviews include the leading academics in the field, lean and Six Sigma pioneers and practitioners from over seven countries. The common themes around the role of operational

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excellence methods in pandemic situations, especially in the light of LL from COVID-19, will be discussed

*Jd Marhveko, vice president of quality and operational excellence at BorgWarner Inc/Master black belt, USA*

LSS often leverages LL. Pandemics have struck our world about every 100 years with some form of documentation of the event. While the ones further back are more anecdotal, scientists have data and records for at least the past seven pandemics. Our current levels of medical science have helped with the overall pandemic survival rate. However, we have a history in which we can formally review these results for future mitigation of impact. LSS can help in its application in at least four broad areas. There are sub-bands of opportunity within these groupings. First, looking at prevention of future pandemics, each past event has had different causals. LSS can be used to review the past facts and data to assess for three things. These include possible causal triggers by leveraging prediction analysis tools, speeding up identification and isolation of an outbreak and finally mitigation of impact in the midst of a pandemic. Past events did not have our worlds' current level of communication and technology. As such, the impacts of past pandemics were much more significant. These can be mitigated with LSS by design and development of effective and efficient communication of behaviors to avoid the illness and mapping of critical process flows to increase the speed of development of medical solutions to the outbreak. Two generations can elapse before a new pandemic arises; how can these LLs be kept relevant in our education and medical systems? Our military has a reserves system to call upon during an emergency. Use LSS to create a set of "health core" reserves to enable diversionary support. Each country "does its own thing" in a pandemic. . . some much more successfully than others. Globally harness best in class results to share via a humanitarian methodology so all can potentially benefit.

Leveraging data and technology to manage the economic impacts to business while people are self-protecting. In the United States, the economic impact has been devastating to lower class families and minorities. With revenue losses of 25–40% in many forms of industry, LSS had to be heavily leveraged in its more traditional forms. It is important to identify high risk groups and design standard work to support these areas differently to improve results. Also, it is important to manage supply chain optimization as countries were impacted individually creating a staggered wave of impact. As some recovered, others were just starting in their wave. This created a "product tsunami" of feast or famine generating significant waste. Another important factor is improving technological support systems for people working from home as well as technological interfaces for communication. Redesign factory/work environment layouts to minimize contact and training all personnel, regardless of industry on how to use and leverage LSS. Overall, a very small percentage of professionals have effective LSS skills. Personnel in all areas of industry need training, so they can begin to evaluate systems now (in our current response) and for designs in the future.

Pandemics affect everything and everywhere. LSS is an agnostic set of disciplines that can be applied to any industry or process. The discipline of this process can help predict, prevent and mitigate some of the deadly results we have witnessed in our generation.

*Richard Keegan – adjunct associate professor of operational management, Trinity College Dublin /director Seraph consulting, Ireland*

The current reality being faced by our healthcare and key workers are very challenging. We can and should be using lean and Six Sigma or whatever else you want to call basic process improvement methodologies to help these people to fix, improve and transform their delivery. We expect our medical people to be experts in their professional field; after all, their area of expertise has trained and worked in the space. Maybe we should not expect them to be



experts in continuous improvement activities. They are usually not trained or expert in this branch of management science. For many years, I have been using a medical analogy to describe CI's fundamentals: diagnosis and medicine. I was suggesting benchmarking, the capture of objective data and comparisons, to effectively identify areas for improvement. The use of lean and Six Sigma can be used to drive improvement. It is timely for this medical analogy to be applied to medical practice. lean and Six Sigma are ways of objectively identifying the core issues within a process and supporting the drive to make things better. All medical practice is a process. From the early registration of patients and the capturing of patient history to the most sophisticated surgery. They are all processes. This means that they lend themselves to analysis and development using the core concepts, tools and applications of continuous improvement. Some early adopters are using these techniques around the world. The time is now right for their widespread adoption in the severely stretched medical world.

*Colin Barr – LSS master black belt and director of Colin Barr Associates, United Kingdom*

If ever there was a problem where LSS tools could and should be adopted for the benefit of society, it is the COVID-19 crisis. I have no doubt that Six Sigma tools such as designed experiments are being used to create an effective and safe vaccine, but there is also a role for these methods in understanding what the important factors are in the spread of the disease human-to-human or human-to-surface-to-human transmission. Statistical process control techniques can surely be used as a way to track and determine changes in both the behavior of the virus and the behavior of our populations. These measures and data can be utilized to help to adopt and inform our levels of social distancing, size of gatherings and where we should travel. Risk management utilizing FMEA will provide a systematic method of understanding and mitigating the risks we face in the workplace and in other interactive situations.

*Professor Jiju antony – professor of quality management and LSS MBB, Herriot-Watt University, Scotland, United Kingdom*

Current epidemiological approaches toward COVID-19 are based on sound objectives: identify the cause and or contributing factors, determine the extent of the virus, its progression in the global population, assess preventive and therapeutic measures and develop an effective public-health policy response. Although the tests for COVID-19 are available in most countries today, times for testing can take from hours to days. Keeping variance as low as possible and eliminating root causes for the variation is key in an integrated approach (i.e. LSS) on mitigating and managing COVID-19.

With regard to COVID-19 testing, a DMAIC project could explore strategies to improve the testing process, both in terms of reducing the turnaround times using simple and effective tools of lean such as value stream mapping and how accurate the results are for patients using Six Sigma tools such as correlation, regression analysis, hypothesis tests, etc. Several LSS tools such as of voice of the customer (Patient) analysis along with the Kano model can be used to understand the expectations of patients and what might delight them. Understanding processes through a simple process map and value stream mapping helps in understanding how nonvalue add can delay the testing process and treatment processes. Identifying the potential causes of variation in turnaround times and determining the errors and defect rate of the process can be useful for LSS. Monitoring processes to ensure they are statistically controlled or not. We should continuously monitor the new, established process and determine whether the processes are statistically controlled or not.

Developments in information technology have the potential to improve the DMAIC approach further, taking advantage of the data revolution, tracking confirmed cases to

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prevent any further infection or transmission. Testing performance and process capability can prevent type I and type II errors in testing, which can lead to false-positive and false-negative results, respectively. The Six Sigma methodology can also be used to support conventional clinical methods through hypothesis testing. Optimizing for testing improvements and sustainability through rigorous control of the process parameters in building an effective test may also utilize artificial intelligence and predictive analytics.

A framework like DMAIC, which is based upon rigorous attention to quality, involving subject matter experts and organized within the domain of LSS, can provide the structure needed. Combining these approaches has the potential to successfully address at least one area of COVID-19 uncertainty: the process of testing.

COVID-19 has changed society as we know it. Working from home, dealing with sudden changes, countries going into lockdown or even denying the threats of COVID-19 all these occur. The question remains how to deal with this and how LSS can help in continuing businesses.

In the first place, working remotely urges companies to rethink the way they manage their people. In traditional systems, management is based on the general principles by Henry Fayol (1916) like division of work, authority and responsibility, discipline, unity of command and unity of direction. "Respect for People" principle is one of two pillars of the Toyota Way (Emiliani, 2008) and respect means that people are the key to successful operations. Management does not require people to be managed: people must be facilitated. Organizing processes in a lean way means empowering the workers and constantly developing people and leading them in a common direction (Nakane and Hall, 2002).

In the second place, workplace management helps to keep social distancing and prevent spreading the virus. Visual management, working with colors and areas where to work contributes to keeping distances. Using lean methods like the visual workplace (Hirano, 1995) reminds people what to do and where to go. This way it is easy to prevent people walking into each other and having a discussion on what to do.

In the third place, huge costs are involved with inventories. Inventories cost money, and minimizing inventories is a way to improve the working capital (Harris, 2005). An important lean principle is just-in-time (JIT), having near to zero inventories (Hall and Hall, 1983) and creating an ideal situation in which sales finance inventories, improving the companies' cash flow. In times when cash flows are going down, lean companies equipped to JIT and zero inventories have an advantage. Shingo compared inventories to drugs: the more you have them, the more you need them (Robinson, 2017).

In the fourth place, processes organized in a lean way are better, easier, cheaper and faster (Roser, 2016). COVID-19 has caused an economic crisis, created by a simultaneous demand and supply shock (Fernandes, 2020). Ohno, considered the founding father of the Toyota Production System said that "all we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing the timeline by reducing the nonvalue adding wastes" (Ohno, 1988). Companies which have "leaned" their company and processes have an advantage over companies, which are not organized this way.

Last but not least, the use of data enabled by Six Sigma enables companies to use predictive statistics to anticipate trends and patterns and actively look for opportunities by applying correlation, regression and Doe (Antony, 2011). Companies using the integrated strategy of lean and Six Sigma have more savings than other companies that use other methods (Antony *et al.*, 2004). Companies using the combined strategy will be better prepared for the current challenges than companies which are not using lean and Six Sigma.

*Associate professor Ayon Chakraborty – associate professor in LSS, Indian institute of management, Tiruchirapalli, India*

Operational excellence methodologies such as Lean, Six Sigma and LSS are around for decades. These methodologies have been tried and tested in various industry sectors such as in manufacturing and services. They have also been used as strategic initiative by different companies, and it resulted in significant benefits for companies worldwide.

In 2020, COVID-19 has emerged as a major pandemic, which has brought the world almost to a standstill. This has resulted in an unprecedented situation for business worldwide. Different sectors have seen issues or challenges emerging in various functions of the businesses such as HR, finance, marketing, operations, etc. There is a need to rethink on the existing strategies for the businesses and develop systems, which can not only help in coming out of the present situation but also prepare them for future eventualities of similar or more critical in nature. LSS is an ideal methodology in this situation as lean helps in reducing waste and Six Sigma in reducing variation. So, keeping this in mind the future processes and systems need to be almost variation free and should support minimal or no waste. The pandemic has shown that businesses now have very little room for errors, and they have to think critically and also survive and perform within the given constraints. LSS provides enough tools and techniques for businesses to work with and develop processes and systems which not only ensure error free products and services but also efficient and effective utilization of resources.

*James Joseph Waskiel – LSS master black belt, ZfR M&A engineering consultancy, Copenhagen, Denmark*

There are many LSS strategies and tactics that apply to address the COVID-19 pandemic crisis. These methods can be used throughout the COVID-19 life cycle. A disciplined DMAIC methodology approach can help in understanding the plethora of true root cause characteristics, variations and mechanisms of the disease from dynamic and contingently complex and chaotic environments. Statistical and contingency risk analysis can be utilized to predict the direction and magnitude of the virus's spread and distribution. Statistical analysis can also lead to identifying emerging patterns in testing strategies and tactics. Anticipating and optimizing processes through design for Six Sigma (DFSS) methods can help establish where failure and risk can occur in patients' treatment in public-health settings. DFSS aids in designing contingency and mitigation strategies to resolves identified issues. Establish and maintain clear measurements of testing times, number of people tested, number of incidences, number of patients in intensive care, variation in testing times, etc. The analysis of this information will help to drive improvements in both COVID-19 treatment and infection prevention.

*Alessandro Laureani – process management leader, KBC Bank and LSS master black belt, Ireland*

The pandemic poses immediate healthcare challenges coupled with long-term economic effects, for which LSS can help. From a healthcare point of view, quick and reliable tests results, coupled with an effective contact tracing, are key to slow down the spread of the disease; however, most of the countries are struggling with these operational challenges: LSS can help in reducing turnaround time for tests and implement a more effective contact tracing.

From a more general economic impact, entire sectors must rethink how they deliver goods or services to customers. Many activities are moving from in-person to virtual, but not enough focus is often put on how the processes and procedures need to be updated in light of this new way to conduct business, and this is a key strength of LSS. All premises with public

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access need to completely redesign their access flow to be compliant with new health and safety requirements: this is where operational tools like 5S can be extremely helpful. Entire supply chains need to be transformed to keep the flow of goods and services going during the pandemic, in the face of a shifting transport, customs and border situation. Again, this is an area where LSS can help. Overall, the operational rigor of LSS can help in smoothing the healthcare impact of the pandemic and allowing businesses to reinvent themselves. After the pandemic, a long-term challenge will be how to embed these skills into schools and universities' curriculum.

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*Dr. Ronald Fite – LSS master black belt, Fite's professional services, North Carolina, USA*

LSS tools that could be utilized everywhere to aid efforts contain the spread of COVID-19. We are dealing with a virus that is invisible. Symptoms are not always apparent. The means of transmission has been determined to be primarily airborne, with secondary contact to the face. Data analysis is vital to identify patterns and testing accuracy. LSS tools, such as Ishikawa's cause and effect analysis, as well as other analysis tools, are vital to root cause reasons for transmission. These tools play a role in clearly understanding risk areas in people's professional and personal environments. Since we currently have no prevention or cure, we must rely on containment via mistake proofing or poke yoke. Our challenge becomes convincing people of the need for change (and improvement). As people are very resistant to change, Six Sigma and lean play a role in helping people change via errorproofing and making environments safer. If we are going to reduce the COVID-19 death rate, a change via utilization of operational excellence methods is important.

*Professor Shreeranga Bhat – professor at the department of mechanical engineering and LSS master black belt, St Joseph Engineering College, Mangaluru, India*

LSS can address the following performance indicators (PIs) of any organization toward operational excellence during the prevailing pandemic situation both from the perspective of manufacturing sector and service sector with special reference to hospitals treating COVID-19 patients. Consider the eight wastes of lean and how these wastes and lean thinking can be applied to make a healthcare environment more productive, optimized and value add in terms of patient care and safety. Defects or errors in the work in process (WIP), and final products that do not meet the customer's requirements can be fixed through LSS, which assists the organization to reduce operational cost. Also, LSS would help the healthcare sectors to curb the erroneous work such as medication errors, rework, variation of outcomes, surgical errors and streamline the process to provide better service to COVID-19 patients. Overproduction measurement in a manufacturing sector would help the organizations to excel in production by minimizing the extra production. This can be attained by optimizing the supply chain and ensuring circular economy. In addition, at hospitals it reduces the redundant work such as duplicate medical record preparation, charting, processing multiple of multiple forms with same information, etc. while treating the patients. Waiting is another nonvalue added waste, and the power of LSS lies in the optimal utilization of man, machine, methods, money and materials. Analyzing waiting times can reduce the people, machine, and information idle time. Application of LSS in health service will assure minimized waiting time for procedures, surgeries and reports, which in turn makes sure availability of beds to all the COVID-19 patients. In terms of nonutilization of talents, LSS will assist the organizations to scientifically reduce the workforce or to effectively utilize the employee's abilities through upskilling and reskilling activities. Besides, at medical centers, proper planning of activities/training will reduce heavy reliance on physicians, unnecessary appointments and assists in getting improvement ideas from the frontline workers. Transportation waste reduction will improve the productivity by reducing the unnecessary transportation of raw materials, product or

information. Further, LSS will help to reduce excessive travel for samples and specimens to be required, excessive transporting of patients for testing, etc. in the healthcare sectors. Inventory reduction will be assured by adoption of LSS strategy with reduced WIP that is not directly related to a customer requirement in the manufacturing industries. Whereas it would ensure minimized length of stay, quicker bed assignment and lab results in the healthcare scenario. Motion reduction would not only improve the performance of the system by curbing the unnecessary movement by people (traveling, searching and walking) in manufacturing sector but also reduce the efforts in looking for patients, missing charts, variation in procedures, sharing of equipment, etc. in the healthcare sector. Extra processing elimination using LSS is directly associated with value preposition as it makes sure only value-added activities are in the product/process. Moreover, it will reduce the nonvalue-added activities in the processes of the healthcare delivery that do not add value from the patient's perspective such as clarifying orders, missing medications, etc.

*Dr. Marcelo Machado Fernandes – LSS master black belt and Scrum Master – MF consultants, Brazil*

From my experience, LSS and agile methodologies will play an even stronger role in terms of operational excellence in the post COVID-19 era. Due to the nature of an outbreak (pandemic), it is inevitable that organizations will be more equipped with resources to solve problems in a VUCA (volatility, uncertainty, complexity and ambiguity) context. And here is where agile methodologies will play a critical role in terms of being prepared to rapidly react, for example, to adjust production capacity to demand reduction, rebalancing workload, adapting workforce and very likely increasing the application of techniques like flexible manufacturing systems. But it is very important that the leaders do not misunderstand being agile with just guessing in terms of identifying root causes of the problems. These are two very different strategies. That is why LSS in conjunction with agile methodologies can be an extremely powerful combination because at the same time belts can speed up the investigation process to solve systemic problems; nobody wants to miss out the real root causes of the problems and waste resources when taking actions to solve problems.

Based on my experience and from what I am observing, I truly believe that in this post COVID-19 era, concepts like minimum viable product (MVP) during project selection, project prioritization, solution design and solution implementation become even more relevant. The waterfall approach is presented in the DMAIC framework and an interesting thing I am consistently observing is that after define and/or measure phase after the detailed process map is presented, LSS practitioners are addressing “quick wins” or “low hanging fruits” more strongly in order to reduce project cycle time. It does not only reduce project cycle time but also introduces a nonlinearity component to the DMAIC framework as agile methodologies recommend. It is a strong win-win region involving LSS and agile and for some reason I am observing this specific practice more frequently among belts in their projects after the pandemic came in.

*Dr Bart Lameijer – assistant professor, operations management, University of Amsterdam, The Netherlands*

In these times of uncertainty, physicians and politicians must respond rapidly, and decisions often need to be made based on limited data or understanding of both causes and consequences. In such situations, agile applications of LSS principles and tools are essential. When these are applied in a more iterative fashion for process improvement, instant learning by doing is enabled. For example, opportunities to improve a process are identified, prioritized and treated independently. After the root causes and solutions for the initial opportunities are understood and implemented, the approach is repeated for the next

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opportunity. Examples may include designing and executing daily experiments for multiple process setups for disease-testing purposes instead of performing complete root-cause analysis. Also, applying nonpareto principles-based rapid root-cause solving in hospital entrance patient care selection processes instead of performing a full exploratory root-cause analysis will be important. The essence lies in obtaining factual insights that allow for quick solutions for parts of the problem. Clarity of critical to quality metrics is crucial to help understand the problem, measure the problem, help direct resources and prioritize areas. Utilizing key measures helps continuously monitor the impact of problem-solving iterations.

*Dick Keely – LSS MBB, management consultant (future perfect Ltd.) and former CEO of Irish Centre for Business Excellence, Ireland*

I believe that LSS methodology is very valuable in the fight against COVID-19. FMEA is a very useful LSS tool to help most businesses assess risk and improve safety in COVID-19 times. FMEA has many advantages; it is easy to use and understand, and it gives a standardized team-based approach to risk assessment, risk mitigation and risk-tracking. FMEA/risk assessments can be used as the basis and foundation for crisis management, business continuity plans and even for communications plans. I would strongly advocate the use of Six Sigma team-based problem-solving (A3) for addressing specific issues that arise.

FMEA and risk assessment can help in identifying mission-critical areas, e.g. materials, people, processes, systems, customers, components, suppliers, etc. in healthcare environments. Workplaces and healthcare facilities can be subsequently error proofed, risk mitigated and contained. Risk analysis can help to prioritize, identify and mitigate especially against the high-probability and high-impact risks.

I would strongly advocate the use of Six Sigma team-based problem-solving (A3) for addressing specific issues that arise during COVID-19 and helping identify rapid root cause and corrective actions. Problem-solving also aligns with FMEA to develop mitigation, contingency and containment actions. Lastly, measurement, analysis and reporting of data and metrics around the spread of COVID, predicting behavior help not only communicate the status and progression of the virus but a direct resource to the problem area and drives corrective actions.

*Dr Sean Moore – senior lecturer in LSS systems, University of Limerick, Ireland*

There have been several criticisms of lean approaches given the recent pandemic. These criticisms are both unfounded and perhaps naïve and come from those who do not understand the philosophy of lean. Disasters/pandemics are produced as evidence that lean does not work, and it is true that supply chains are affected by these unforeseen events. “Black swan,” a term introduced by Taleb in 2010 to describe these events, indicated that they are rare and tend not to be predictable. Therefore, 99.999% of the time, in the normal scheme of things, lean works fine, but when rare extreme events occur, the benefits of lean supply chains become its Achilles heel. Critics of the lean approach would, therefore, trade back or abandon the philosophy based on 0.001%!

If we do trade back or abandon the approach, what is the alternative, go back to having large warehouses of materials to avoid interruptions? What materials should we store? What rare event should we prepare for, or should we prepare for them all? What financial/company resources should be tied up in these massive warehouses, and where should we locate them? How many different suppliers of one type of material should we have feeding our supply chains, and where should they be located? In fact, there is no alternative to lean supply chains and to use a rare event as evidence against the philosophy demonstrates a failure to understand it.

However, there is evidence that one aspect of lean organizational behavior was unsuccessful during the recent pandemic, and that was the failure to utilize horizon planning. It was evident that the pandemic could become a global phenomenon, and organizations could have completed short- and medium-term assessments of its potential impact and prepared accordingly.

Taleb (2010) indicated that organizations that scan their business horizon continuously at least have the opportunity to anticipate events once evidence is starting to emerge. If they then have the courage to take an asymmetric (low cost/high gain) bet on what could potentially happen, they can mitigate the worst effects. A dramatic example of horizon planning working was the reaction to the oncoming pandemic where the health service in Ireland with a 400% increase in the ICU capacity and ramped up testing to 50,000/ week. Another example is the recent purchase of the world stock of Remdesivir by the United States.

Finally, if evidence was needed for the benefits of lean, one only has to look at the robust maintenance of the food supply chains, which, once deemed essential, keep food on the shelves. Besides, a value-added approach is been taken by vaccine developers and regulatory authorities with the elimination of nonvalue-added delays, which should shorten the development time. No supply chain philosophy can deal adequately with “black swan” events and reject a philosophy with a proven track record of nearly 70 years, and one which has permeated almost every aspect of modern life demonstrates a fundamental lack of understanding in the lean thinking philosophy.

### **Discussions and implications**

All respondents emphasized the importance of operations excellence methodology in addressing problems in COVID-19 times. While some respondents were more in favor of Six Sigma methods than lean and vice versa or a mix of both, the common denominator was that the tools and techniques of these powerful operational excellence methodologies have an immense role in protecting public safety and healthcare environments.

The themes of operational excellence methods are thought of as a common sense and a process approach for ensuring public safety and improve healthcare treatments and testing was throughout. Risk assessment using FMEA for minimizing infection risk, providing contingency and mitigation plans was a common theme. Statistical analysis and measurement of data have a role in measuring, managing and understanding infection rates and prioritizing areas of concern. lean and nonvalue-added waste elimination and error-proofing can help in infection prevention. DMAIC structured problem-solving is important to brainstorm and provide preventative and corrective action in COVID-19 type public safety and healthcare treatment and testing situations.

The findings from this research are a valuable source for clinicians, medical directors, consultants and nurses in hospitals and healthcare settings. The research demonstrates a link between operational excellence methodologies in helping treat, prevent, diagnose and mitigate against pandemics. The LL from the application of operational excellence methodologies have relevance to and practical applications for healthcare settings in aiding preparedness for pandemic situations. Operational excellence methods and elements thereof as described in this article have been proven and effective in many environments and not just healthcare and applied will enhance patient, staff and public safety and treatment efficiency.

In summary, the concepts of using structure problem-solving and continuous improvement methods to assess risk, understand processes, eliminating nonvalue-added steps to prevent infection, expedite treatment times and coupled with error proofing are recurring themes throughout.



### Conclusions, limitations and future work

Operational excellence methodologies, in particular, lean and Six Sigma have the potential to address some aspects of uncertainty in COVID-19 times, enhance understanding and provide practitioners and academics in the field with effective guidance to mitigate and manage COVID-19.

The two key findings from the study are as follows:

- (1) The discipline and methodology of operational excellence can help to treat, prevent, diagnose and mitigate during pandemics as well as improving healthcare process efficiency.
- (2) LL from previous pandemics can be integrated with operational excellence methodologies to aid preparedness for these events.

Opportunities for further exploration of the use of operations excellence methods in a pandemic include further case studies on applying these methods in public safety and healthcare environments now that some countries have lowered their infection rates. Further research via more detailed interviews and surveys on the application of these methods with a wider section of stakeholders would be very valuable in informing on how methods such as LSS Six Sigma, lean, agile and leagile were applied in the COVID-19 pandemic.

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