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A Risk Management Framework Using Digital Transformation for the Healthcare Sector during the Covid-19 Pandemic

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Acronyms

HC: Healthcare

RM: Risk Management

RMP: Risk Management Plan

MOH: Ministry of Health

PPE: Personal Protective Equipment

HER: Electronic Health Record

DT: Digital Transformation

AI: Artificial Intelligence

AR: Augmented Reality

ML: Machine Learning

VR: Virtual Reality

AGV: Automatic Guided Vehicle

ASRS: Automatic Storage and Retrieval System

RWD: Real World Data

RWE: Real World Evidence

RR: Risk Register

ANOVA: Analysis of Variance

DAAP: Data as a Platform

Abstract

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Professor Slim Saidi

Despite the many changes in the orientation of the world economy and the spotlight positioning, the healthcare sector remains one of the most important and critical sectors for its contribution in every aspect of human life. Improvements in the healthcare sector are seen and evident on a daily basis to cope with the technological and digital advancements in the world, and the recent COVID-19 pandemic has put these improvements into a faster pace. Several challenges in the health sector have risen to surface since the beginning of the pandemic; some of these challenges have been properly addressed and tackled, while others have shown the flaws in the healthcare sector in several countries around the world. These challenges have come with risks that can be projected on the sector as a whole, and thus this has given researchers a golden chance to dig further deep into more improvements in the sector, to have these risks identified, assessed, and eliminated or monitored in the future.

Digital transformation has recently become one of the most robust tools to improve the processes and operations of organizations as whole and paramount ones in particular. Digital transformation brings however its own risks and thus a lot of research has been previously addressed the risks of digital transformation, whereas no research has yet been done on digital transformation by itself being used as a risk management and mitigation tool despite its effective use as an improvement tool and for other organizational goals. Our research comes to address the main risks in the healthcare sector and to match these risks with monitoring actions that use digital transformation as a tool.

One of the main challenges the healthcare sector has faced during the COVID-19 pandemic, was the ability to maintain ordinary operations while handling COVID-19 cases and controlling the spread of the virus in the healthcare facility. This situation has called for segregation of COVID-19 patients from other patients whether it was in the same facility or by adapting them into different facilities. The segregation of patients has been done using two digital solutions; embedment of automatic thermometers, and the development of an efficient scheduling strategy for COVID-19 symptomatic patients. Furthermore, other challenges have risen due to the pandemic and caused major risks that called for monitoring actions and solutions, whether digital or non-digital ones. To investigate these challenges, a literature review was conducted in this research to highlight the 11 most common challenges that can be included in a survey to be distributed to different healthcare organizations for the purpose of prioritization and ranking of these challenges and ultimately conclude the associated risks based on the results of the survey.

In this research, a survey was conducted with over 100 hospitals inside and outside the UAE to identify the main challenges in the healthcare sector faced during the pandemic. The

survey addressed the challenges that were found in the literature review to be the most impactful on the healthcare sector during the COVID-19 pandemic. These challenges acted as an inspiring source for the associated risks to be identified accordingly based on their impact result from the survey. Furthermore, an assessment of these risks was conducted to evaluate the likelihood of each risk and ultimately the risk rank and priority. The final step in the risk management strategy entailed the recommendation of monitoring actions based on digital transformation tools and techniques. Basing the monitoring actions on digital transformation will pose the trademark of this research and will highlight its originality. Moreover, the survey has also addressed three factors by questions that were answered by the respondents. These factors included the country, the size of the healthcare organization, and its technological readiness. The correlation of these factors with the collected responses of healthcare organizations is investigated using statistical tools to study the effect of these factors on the impact level of COVID-19 on the healthcare organization. This risk management framework will act as a guideline for any healthcare organization Finally, a risk management framework is drawn from these findings involving a risk response strategy and a risk control plan as part of risk registers.

The main and ultimate goal of this research is to outline a recommended management approach to the healthcare sector risks caused by an event of a pandemic in general and COVID-19 in specific. This risk management framework designed in this report will act as a guideline for any healthcare organization of any size, with any level of technological readiness, and at any level outbreak severity in the country.

Keywords: Digital Transformation, COVID-19, Healthcare, Risk Management, Statistical Analysis, Risk Assessment, COVID-19 Impact.

1. Introduction

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2. Literature Review

2.1. Healthcare

Healthcare (HC) refers to all services that medical professionals deliver to preserve people's physical and mental well-being. Healthcare is one of the most demanding yet profit-generating sectors due its criticality and importance. Therefore, healthcare has been for many years one of the main industries of which DT has taken part. [1]

2.1.1. HC stakeholders

The stakeholders of the HC sector can be identified in many ways and from various angles. However, the most common and most influential stakeholders are the following:

1- HC Providers & Management Systems

2- Payers/Insurance Companies:

3- Patients & Families

4- Regulators (MOH)

5- Government

Figure 1 - Stakeholders of the Healthcare Sector

2.1.2. HC Challenges

Identifying the stakeholders of the HC sector is very important to identify the challenges facing the sector from the standpoint of each one of the stakeholders as shown in the subsections below.

2.1.2.1. From the standpoint of HC Providers & Management Systems

Despite the fact that the healthcare sector has undergone many improvements in recent history, it is still a moldable sector that can take even more. A proof of the dire need of development in this field was the COVID-19 pandemic that has taken every sector by storm. The challenges of the HC sector from the standpoint of HC Providers & Management Systems are the

ones to be considered in this research. The HC sector has faced several challenges[2] including the following:

I. The lack of adequate capacity to handle the surging patient volume.

This surging patient volume can overload hospitals with a huge number of patients who can cause a major healthcare crisis in case they outnumber the capacity of ICU beds and ventilators available at hospitals, which may lead to a major crisis.[3]

II. The need for real-time redesign of care models for patients.

Given the highly contagious nature and severity of the infection, it is necessary for physicians, nurses, and other clinicians to discover the appropriate care model and room design.

III. Protection of the physical and mental health of frontline staff.

Hospitals and clinics have to ensure an adequate supply of Personal Protective Equipment (PPE) for their staff. In addition to the risk of contracting the virus, frontline staff have to cope with tremendous mental stress, which some may find unbearable.[4] There have been anecdotal reports of frontline staff dying by suicide.

IV. The huge financial losses.

These financial losses are mainly due to the cancellation of elective procedures and the disruption of routine care, particularly for hospitals already in financial difficulty.[5] (the dilemma of profitability vs. the apocrat sermon)

V. Security and data breaches.

Such breaches are making it difficult for hospitals wanting to upgrade to electronic health record (HER) systems.

VI. Shortage of medical and diagnostic equipment.

VII. The over dependence of the care management systems on manual processes.

VIII. Limited access to data (historical data) [Big data Vs. Small data]

IX. Lack of coordination and limited visibility and transparency between stakeholders [The chain of trust/Visibility is the solution]

X. Lack of data standardization and data sharing

XI. Managing the productivity and quality of remote work delivery.

2.1.2.2. From the standpoint of Payers:

The challenges from the standpoint of Payers include:

I. Sharp increase in claims and enquiries

II. Rising costs with high financial uncertainty

Rising costs are due to higher infection rates (certainty). The certainty of the COVID-19 infection increases uncertainty in the already uncertain insurance industry.

III. Rapidly evolving mandates from regulators

IV. Lack of coordination and limited visibility and transparency between stakeholders [The chain of trust/Visibility is the solution]

2.1.2.3. From the standpoint of Patients and families:

The challenges from the standpoint of Patients include:

I. Fear and mental health issues due to concerns of getting infected by the virus

II. Fear of continuing with regular treatment protocols which may lead to aggravating the current infection rate.

III. Financial difficulties due to rising treatment costs for patients with critical conditions.

2.1.2.4. From the standpoint of Regulators (MOH)

The challenges from the standpoint of Regulators include:

I. Lack of advanced health technology

II. Electronic data and cybersecurity breaches

III. Lack of data management systems

2.1.2.5. From the standpoint of Government:

The challenges from the standpoint of Governments include:

I. Lack of proper infrastructure to take appropriate measures to tackle such a pandemic

II. The slowdown of the global economy and its effect on governments, which exacerbates governments inability to provide financial support for HC systems and facilities.

III. Social justice/injustice [Policies Vs. Impact of policies]

2.1.3. Healthcare Solutions

The challenges that have faced the healthcare sector during the COVID-19 pandemic have been encountered by several countermeasures and mitigation actions that include

telehealth solutions, remote work delivery, and redesign of conventional medical care models. These countermeasures have partially succeeded in acting as mitigating actions to the challenges faced by the healthcare sector, however, their mitigating impact has been a short-term one that has not successfully provided an alternative for conventional medical care models. Furthermore, the severity of these risks in terms of the risk rank is mainly affected by the types of solutions and mitigating actions enacted and enforced in the healthcare facility. Telehealth solutions and remote work adjustments can backfire when the process of resource allocation and rightsizing is unparalleled with the number of patients, the size of the healthcare facility and the technological readiness of the facility.

Therefore, the establishment of a digital-based risk management framework comes up to stand out as a necessity in a world that's currently dominated by technology that never fails to surprise the world with the magnitude of its interference in its everyday operations. The diversity of digital solutions nowadays, makes DT an essential tool in enforcing communication, cooperation, collaboration, innovation, and problem solving. This interdisciplinary power of DT as a tool legitimizes its credibility as a risk management technique that is able to control both the assessment and the monitoring phases of risk management. The implementation of digital-based healthcare solutions entails the use of combinations of tools like ML, AI, robotics, RWD, and block chain in the diversification of risk assessment techniques, risk mitigation strategies, and risk monitoring actions.

2.2. Risk management

The effectiveness of risk management is an issue of timing. Risks should be reduced or eliminated at an early stage, but managing these risks must be performed during the complete life cycle of the project. This approach applied as early as the very beginning of any risk management project. Risk that stems out of the base is a risk that is quite hard, late, and too aggravated to tackle when the project is already past the preliminary stages.

At the beginning of any project and while the scope and the deliverables are being set, the potential risks of the project are identified for proper preparedness for any potential uncertainty. These risks are identified, assessed, and acted upon in a process called risk management. Risk management is a very important technique that enhances the overall project management process by ensuring that deviations are detected and proper corrections are prepared beforehand. The risk identification step in risk management is the simplest step whereby the potential risks are listed based on historical data and previous projects of similar nature. While the risk assessment phase is a bit more of a deeper research into the different perspectives of the identified risks in terms of their impact and consequences. The risk assessment process can be either qualitative or quantitative depending on the type of project, its activities, and nature. Quantitative risk assessment usually involves a probabilistic or a statistical analysis that quantifies the risk by estimating its probability of occurrence and then prioritizing risks based on their severity and likelihood. The final phase of risk management is the risk control, whereby solutions, actions, and best practices are recommended to encounter risks at their early stages and eradicate them before they develop into higher priority risks with high severity. Project related risks can be anything from the smallest and

most trivial uncertainties, to the largest and most complicated problems, challenges and complications.

There are various types of risk that might be encountered in the HC sector. Many risks are pertinent to the sector as a whole, while many others have only been encountered during the COVID-19 pandemic. The lack of adequate capacity to handle the surging patient volume for instance has posed a key challenge and led to various risks including the overloading of hospitals and HC systems as a whole. Identifying the risks of a pandemic on the HC sector is an important deliverable at the beginning of the breakout while risks are still manageable and can be palliated using light countermeasures. However, the nature of the pandemic and the fact that it has been nothing but an unpleasant surprise to the whole world, it may have been only possible to learn these lessons the hard way. Therefore, this research is conducted for a deeper investigation of the challenges faced by the HC sector during the pandemic and the associated risks.

After the risk identification phase conducted in the LR and verified through the survey, risks are prioritized so that those with the highest priority are assessed for further investigation of their impact, severity, and likelihood. This assessment is done based on criteria developed and adjusted based on the project requirements. Furthermore, this risk assessment process presents a solid approach to the final risk management phase that entails monitoring, incorporation, and balancing of prioritized risks.

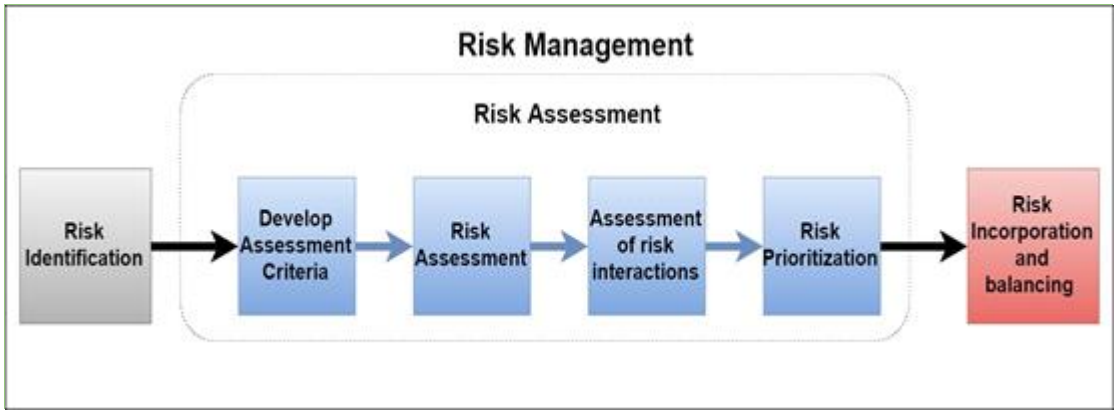


Figure 2 - Risk Management Flow Diagram

2.3. Digital Transformation

2.3.1. Definition

Digital transformation (DT) refers to “a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies”. [6]

Digital Transformation is a concept of a wide horizon that cannot be confined in the narrow circle of an organization or business. It is more of a comprehensive concept that includes people, societies, governments, and even countries. The closest and most accurate definition of Digital Transformation (DT) is the integration of digital technology in all areas of a society, regardless of the size or type of the society. DT utilizes technological advancements to develop the abilities and capabilities of a society from regular, analog, and traditional to digital assets that level up the capacity of this society to communicate, perform, assimilate, and cope up with this fast-paced world. [7]

Furthermore, DT should not be confused with the general use of technology for purposes that do not serve into the development of a society or its growth. Digital transformation is more of a technical terminology that best fits in nowadays-global pursuit and endeavor for an easier world that molds the shape of technology to a suitable form that revolutionizes and grows our potentials and understanding as individuals, organizations, and societies. [9]

A great example of digital transformation is a service company’s plan to transform its customer service operations from manual to electronic. This example

comprises many aspects of digital transformation including the organizational, environmental, financial, cultural, and data aspects. These Digital Transformation aspects are best categorized using the following components:

2.3.1.1. Organizational:

The organizational aspect of DT is a holistic reflection of the change in all the processes, operations, structure, and communication in any organization. An organizational DT is manifest when a root technological change is implemented to the internal and external communications between the management, employees, customers, end users, and suppliers. It is also witnessed in the form of a fundamental change to the internal and external processes and operations that involve all the stakeholders in the organization.

2.3.1.2. Environmental:

The environmental aspect is a crucial component of DT as it accompanies most DT projects. In the example of the company that's transforming to electronic services, the use of paper and physical data storage tools will be substantially reduced. This is not all, this company will not only save its customers a fuel tank, but it will also do the environment a favor by reducing the number of carbon emitting car trips by a few. In addition, the impact of the ink used in printing documents is negative and disastrous to both workers, users, and the environment as a whole.

2.3.1.3. Financial:

The ultimate goal of any organization is to reduce its costs and increase its revenues. It is important to address the importance of achieving this while maintaining the quality of products and services. DT, of all types, introduces tools and techniques that balance the value stream map of any organization. DT maintains and even endorses the value of an organization's services and products and suggests cost-reducing and sales-boosting strategies. Despite the fact that it is sometimes costly to enforce DT into an organization, the results will always make it feasible if selected, planned, and implemented at a high caliber.

2.3.1.4. Educational:

The influence of DT on the world amid the Covid-19 crisis, gives a clear idea about the advantages that DT can bring to the world. Not only the speed of transformation was impressive, but also the ability of the world to adapt to this transformation and make the best use of it. While Covid-19 took a toll on most businesses and life aspects, education did not stop. Even some war-torn countries kept it up and going in the education field because internet has with no doubt become a life essentiality to billions of people around the world. The DT in education had its own success makers who took it to the next level in terms of the tools and platforms that managed to keep the educational process smooth and running. However, the adaptability of organizations and individuals to this fundamental change has been the highlight of this era.

2.3.1.5. Data:

The photo of Bill Gates advertising CD ROM back in 1994 sticks in the mind of millions of people who thought that day was the day the whole world has just witnessed its biggest change. The ability to save 737 MB of data in one small rounded disk had been a turning point to millions of people whose children now can wirelessly exchange thousands of times more data and even complain if it took few minutes longer than expected. DT comes along robust tools to exchange data through various networks all around the world. These tools do not only enable users to store data, but also access this data from any part of the world at a very high speed and quality. This aspect of DT is the most revolutionary and futuristic because it is developing at a very high pace and is a helping hand in building a huge database that can predict patterns of behavior for humans, societies, organizations, markets, and pandemics.

2.3.1.6. **Cultural**:

The cultural aspect of DT represents the influence of DT on the culture, mentality, and behavior of individuals, organizations, and societies. When a process is digitally transformed in any organization, it is essential to maintain a parallel change in the culture of this organization. A sudden implementation of a digital transformation cause an organizational cultural shock that may lead to the failure of the transformed process or the organization as a whole. Therefore, an organization should be able to adapt to cultural changes and maintain a smooth transition from analog to digital.

2.3.1.7. Social:

When all DT aspects tend to be more positive than negative, the cultural aspect of DT is more of a negative one. This statement is imputed to the ability of today's technology to replace humans by machines that are able to do outwork a highly-qualified human employee. The social impact of DT extends to its influence on human relationships and interactions that can easily be replaced by a keyboard or a microphone. In spite of the fact that DT is meant to serve in improving the quality of services, it is only doing that and is not adding much to anything else outside the organizational circle. Thus, the question that rises nowadays is, aren't we better off like old days?

In conclusion, DT is an organization's choice of exploring new worlds of developments and advancements. However, it is a difficult choice for its potential to rocket the company into a world that requires maximum capacities and efforts to sustain success and keep up with the light-speed improvements. The choice of the type, size, and speed of DT that an organization is willing to implement, identifies the success of the transformation. It is best to plan for DT and take think it out seriously and deeply before implementing it because it usually comprises a radial irreversible change in all of its aspects to all stakeholders in an organization.

2.3.2. Digital Transformation in Operations

While Digital Transformation (DT) is a wide-horizon concept that exceeds the limits of organizations, businesses, and social life, the focus of DT has transformed in

recent years into an organizational technique that helps organizations reorganize their structural hierarchy and operational strategies. DT has become an efficient tool to improve the internal communication, networks, flow of work, and long-term strategies and planning.

Digitally transforming the operations of any organization is not a simple process; not only in terms of the transformation procedure, but also in terms of the preceding decision making process. An organization needs to plan very carefully for a DT, and even more carefully and thoroughly for a DT of operations. This vigilance in planning and implementation is attributed to many factors that include the specificities of an organization's operations, the nature and type of operational DT, and the level of digitalization already achieved.

DT of operations has started to emerge into the new world of business in means of online communication, paperless documentation and digital database management. However, the technological advancements in the recent years have surpassed the expectations and limits, whereby the integration of technology has become a prerequisite for any organization to cope up with the very high speed of the world we currently live in and to live up to the expectations of the customer. Therefore, paperless documentation and wireless communication are no longer able to identify the advancement of operations DT and are merely ordinary everyday tools without which an organization cannot survive the current business world.

Digitalizing operations in its modern definition is done through moving to platforms that provide a common ground of communication and interaction between the

organization and its clients. The idea of a platform is initially to connect individuals of all types together; product/service providers on one hand and end users on the other hand. These digital platforms are online platforms that bring the whole world closer to any organization regardless of the type of industry to which the organization belongs. Such industries include education, healthcare, commerce, finance, consulting, media, and government. Furthermore, these platforms are required to be customized to the needs and specificities of the industry by providing the proper network to connect the end users with the providers in a timely, cheap, easy, and organized manner.

A good example of such platforms is the digital inventory planning systems that have become revolutionary at the end of the last century. These digital systems have helped in providing a database for both the provider and the user to refer to and retrieve information about inventory levels and validity periods. These inventory control systems have revolutionized the use of technology in logistics and supply chains, and have introduced means of communication and data accessibility between different employees inside the same organization as well as customers.

Digital platforms do not necessarily have to be interactive, as long as they provide an efficient stream of communication. An example on this is cloud services that have played a substantial role in improving organizational performance in terms of big data storage, mining, and retrieval. Despite the fact that many people would deem both examples (inventory control systems and cloud services) as communication lacking, they however provide and facilitate a communication that exceeds the limits of ordinary connection of end users and providers. This premise should not refute the fundamental concept of communication upon which digital platforms are based; it just introduces a

modern concept of communication that involves free movement of data and information seamlessly, timely, accurately, and efficiently.

DT in operations is not only about setting up digital platforms for communication; it is a deeper concept of comprehensive transformation that serves the operational excellence of any organization. The operations of an organization vary depending on the industry and the conventional operational protocol, but some operations are interdisciplinary and are common in principle to those in other industries, which also unifies the DT concepts in relation to these operations. One good example of such operations is the implementation of machine learning and artificial intelligence, which have been of the major highlights of DT in the recent years. An organization in the manufacturing industry is able to apply machine learning to its operations as much as an e-commerce organization is despite the major differences in the implementation approach and type. While machine learning in a factory would be to level up from the automation phase to the smart machine-led automation, machine learning in an e-commerce business would be in relation to the platform the e-commerce business has created to communicate with its end users, employees, and even competitors.

In supply chain and logistical operations, the first step to digitally transform a process is to break it down into segments starting from the planning phase, sourcing phase, distribution, delivery, allocation, storage, and retrieval. Other segments include other supply chain segments including finance, risk management, and asset management. A new revolutionary supply chain DT concept is the supply chain collaboration network. This network consists of different stakeholders which contribute together to the supply chain of an organization by inputting their expertise into the process. The end result of

this collaboration will be an integrated network solution based on various technological aspects and backgrounds.

After the segmentation of a supply chain process, the planning phase takes place whereby the final goal of the process DT is envisioned with all the transformation aspects. The DT should take into consideration the service provided, the cost incurred, the agility, inventory control, and sustainability. The steps points taken into consideration are ordered carefully based on the priority of implementation and required sequence. The service provided by the organization is aimed at the customer who is ultimately the main point of focus for the organization. Once the customer is prioritized and focused on, the organization should steer its focus on improving its agility in a way that enables it to balance its intended quality and added value with its costs that are required to be always optimized to meet the customer requirements. The value analysis is an essential technique that is of high caliber in any organizational operational improvement, as it provides an equation of equilibrium that serves as a guideline for any organization pursuing a balance in its costs on one hand and quality on the other hand. Quality in supply chain is measured by the level of inventory planning, control, and management that an organization is able to achieve while organizing its logistical operations. A high level of control and management of inventory requires a robust digital system that is technologically comprehensive of all aspects, which in turn requires a sustainable strategy to maintain the same levels of quality for long after the implementation of the digital system.

The types of technology used in supply chain and operations by organizations nowadays exceed the conventional technology that has become ordinary to use in

organizations in this industry. These technologies include Artificial Intelligence (AI), Machine Learning, Virtual Reality (VR), Augmented Reality (AR), Automation, Automatic Guided Vehicles (AGVs), robotic material handling systems, and Automatic Storage and Retrieval Systems (ASRS). The proper implementation of DT into operations and supply chain in specific in an organization comes with various benefits to the organization on both technical and managerial levels; these benefits include the improvement of decision making, automation, innovation, end-to-end customer engagement, outsourcing capabilities. Data accessibility and talent acquisition.

The advantages of digitalizing operations do not stop at the door of improving communication and smoothing it out for better user-provider relationship; it exceeds that to involve market competitors and rivalries. The data accessibility that platforms provide has its effects on the competitiveness of an organization in its industry. Outsourcing is no more a consulted matter; an organization can simply outsource and resemble any process by a simple internet search. Although this might not sound sensible and professional, but it is directed to address the seamlessness of data transfer and communication between different organization in the same industry or even different ones. This smoothness in the process is not only meant to enhance the rivalry and market competition in its negative aspect, but it is also meant for an organization from a certain industry to create means of cooperation with other organizations from various industries to collaborate with these organizations, to fill in the gaps, and complete its performance cycle. In conclusion, implementation of DT in operations might not be an organization's easiest or cheapest option, it is however able to improve cross-functional and cross-directional operations, communication, technology, leadership decisions, and is magically capable of an overall

organizational improvement in all aspects, dimensions, and for all counterparts. It is a win-win deal!

2.3.3. Digital Transformation Tools in the Healthcare Sector

Just like every other industry, the healthcare industry, is influenced by digital transformation. It means that different technological tools and solutions are used to enhance the patient experience, service delivery, create new business models, and make communication more efficient. The utilization of digital transformation in the healthcare industry is not solely dependent on technology implementation but rather on how and why can technology be implemented to help the healthcare field grow and elevate.

Even before the breakout of the COVID-19 pandemic, it was expected that the healthcare industry will be facing higher numbers of patients and thus higher levels of preparedness were planned to handle the increase in the numbers. Healthcare entities had to rethink the way they deliver services to their customers (patients) using a robust digital strategy. Not only that, they also had to rethink their strategy in acquiring the necessary staffing. For example, more emphasis was placed on higher skills using technological devices with less emphasis on activities that are repetitive in nature such as delivering MRI scans since such activities can be automated. Of course in redefining their strategies, special attention was paid to other supporting activities such as Human Resources, Finance, Quality, Marketing, etc.

Healthcare organizations must provide whatever means to facilitate access to its services. However, they need to always come up with new ways, including digital ones, to

attract those who seek medical help since customers' habits and behavior rarely stay the same. On a side note but much related to customer retention, the power of employees cannot be ignored. Happy employees lead to happy customers. HC organizations, big and small, can use digital transformation technologies to ensure their employees are included in the change if they were to have happy patients and positive results. "Workplace platforms offer new ways to destabilize attrition rates by helping employees become more engaged with their work and flagging early warning signs, so that managers can intervene before high performers leave as a result of low morals or boredom." [10].

Digital transformation in healthcare is not only a change in the healthcare systems, but also a changing factor for the society as well. Automating systems and processes increases the need for better management, more accurate diagnoses, and more effective treatments. Despite the fact that digital transformation and technology implementation processes are slower compared to digital transformation in banking, for instance, there is a chance to learn more from experience in other industries and even accelerate the process in healthcare based on the available results. In conclusion, the ultimate goal of digital transformation is to create more customer-centered services of great importance in the healthcare sector since the treatment of every patient can become more personalized, thus improving the quality of services provided for patients. Artificial Intelligence (AI), Robotics, Real World Data (RWD), and Blockchain are few out of many digital transformation tools that can be utilized in the healthcare sector.

2.3.3.1. Artificial Intelligence (AI)

Artificial intelligence (AI) and related technologies are increasingly prevalent in business and society, and are beginning to be applied to healthcare. Several types of AI are already being employed by payers and providers of care, and life sciences companies. The key categories of applications involve diagnosis and treatment recommendations, patient engagement and adherence, and administrative activities. However, for a variety of reasons, we believe that it will be many years before AI replaces humans for broad medical process domains.

The application of AI in this research is not specifically in the healthcare sector but rather in the risk management of the HC sector during the covid-19 pandemic. Artificial intelligence is not one technology, but rather a collection of them including machine learning, natural language processing, automation, and rule-based expert systems. [11]

AI with its different variations and applications have been used in many industries but have had a prominent influence on the healthcare sector during the covid-19 pandemic. AI is not merely involved in the medical treatment of patients, but also plays a substantial role in controlling the spread of the pandemic through the identification of high-risk patients, real-time control of infection, mortality rate prediction, and population screening.

The main applications of AI in covid-19 pandemic include the early detection and diagnosis of the infection, monitoring the treatment, contact tracing of the individuals, projection of cases and mortality, development of drugs and

vaccines, reducing the workload of healthcare workers, and prevention of the disease. The role of AI in the early detection and diagnosis is done by analyzing irregular symptoms that may correlate with common covid-19 symptoms and report the results of the analysis to the healthcare provider and the health authorities. AI uses algorithms to expedite the diagnostic decision-making process with the help of supporting screening and imaging technologies. [12]

Beyond the diagnosis of covid-19, AI can additionally help in monitoring the treatment of the disease by using neural networks to extract visual symptoms and features of the disease and then matching them to the symptoms of a patient using smart AI platforms that confirm the diagnosis so that the proper treatment can be decided accordingly. Furthermore, the role of AI stands out in tracing infections and providing an infection cycle map that controls the spread of the virus by providing the ability to locate potential infected individuals. Moreover, AI can also be used in forecasting the number of infected individuals and mortalities based on available data about the infection rate, spread rate, positive-test rate, mortality rate, as well as region-based test coverage and concentration. Beneficiaries of such data projections can take necessary countermeasures and precautionary actions to prevent the increase in spread and infection rate. Therefore, AI has played an important role in predicting potential sites of infection, anticipating the surge and curve shape of the virus spread, and forecasting the need for healthcare providers, facilities, beds, and intensive care units.

The massive capacity of AI technologies in data analytics and big data mining has made it possible for scientists to design, develop, test, and deliver covid-19 test swabs, drugs and vaccines in unprecedented time records. The importance of the time factor in developing a covid-19 vaccine has necessitated the utilization of AI technologies in diagnostic test designs, as well as drug and vaccine development.

An essential use of AI in the healthcare sector during the covid-19 pandemic is in the scheduling of human resources in healthcare facilities. The increased work pressure during the pandemic and specifically at its beginning, has exposed the lack of healthcare professionals who are able to cover the surging need for healthcare providers by the massive number of patients. The importance of proper resource scheduling is not meant to merely reduce the pressure on the healthcare staff, but to also provide the chance for the staff to to do their role in early diagnosis at early stages of disease infection, and to provide the right and timely treatment to prevent aggravated consequences and complications.

2.3.3.2. Robotics

The use of robotics has been widely growing and propagating throughout different industries and fields during the recent years. Robots have taken part in different industries and have managed to operate at high accuracy and precision, proving that science can one day develop a technology that one day will act as an alternative to humans.

The Covid-19 pandemic has necessitated the use of many technologies, even some of them that were underdeveloped and merely under experimentation and research. Such technologies included robotics which facilitate the use of a robot as a shielding layer that segregates the patient from the healthcare provider. The use of robots as a shield has reduced justifiable fear of patients from viral and bacterial spread and infection, as well as contamination especially for patients with low immunity and those undergoing open surgeries. The integration of robots happen at various stages of the pathogen spread sequence, while the ultimate goal of this integration is to minimize interaction and direct contact of the healthcare provider with the patient.

The role of robots is not meant to reduce the role of humans in the healthcare sector, but rather to minimize the interaction by introducing a way that facilitates the communication between patients and healthcare providers. An example of this is the American experience of the first COVID-19 patient in the country, who was isolated in a special room and was communicating with the HC providers through a robot that had a camera, microphone and a stethoscope. The high cost of such technology may be the only limitation to its application in a wider range of healthcare fields, in addition to the low public acceptance to robots providing fully automated medical care to patients.[13]

Despite the revolutional rise of robotics, it is still and will always be a human-dependent technology because a human controller will always be needed to operate a robot whether directly or remotely. Therefore, robotics will never replace a human being without the integration of machine learning into its

operation process. Machine learning is able to program the robotic system based on an algorithm that's able to solve any new problem with a similar pattern to those that have previously been performed using the same algorithm. Nevertheless, the use of robotics even without the integration of machine learning can revolutionize the healthcare industry by eliminating the main obstacle of viral spread in times of pandemics in specific, as well as radiation exposure and pathogenic spread in general.

2.3.3.3. Real world data and analytics

Real World Data (RWD) is a terminology used to describe the live data provided from various data sources regarding a particular population through surveys, questionnaires, trials and observational studies. Such data can contribute to the development of a diverse and comprehensive database in any field of study. The importance of the utilization of real world data in the healthcare field has increased since the start of the COVID-19 pandemic, due to the continuous need of healthcare organizations for updated data about infection rates, tests, protocols of treatments, and other virus-related data that help in unifying and synchronizing knowledge and global efforts in combating the virus. [14]

The importance of RWD in the HC sector stems out from the growing need for the transparency of all stakeholders involved in the COVID-19 pandemic in general, and in the HC sector in specific since it acts as the main source of data. The data collected from different sources serves into creating Real World Evidence (RWE) using the knowledge developed about the COVID-19

virus and its spread in HC facilities around the world. This data is solicited from millions of patients around the world through EMRs, medical reports, contact tracing APPs, viral testing centers, and insurance data. The type of knowledge collected using RWD includes viral behavior prediction, treatment protocols, treatment costs, symptoms, viral infection rates, and other health complications associated with the disease. The enablement of RWD is done by the development of blockchains that connect a large number of datasets from different HC organizations together using AI technologies that expedite the access of these HC organizations to the data provided by each one of them. The HC organizations need to use advanced techniques of data analytics to prepare data efficiently in real-world healthcare settings and present it in a robust blockchain for the access of other organizations that will benefit from this data in understanding the COVID-19 disease, treatments, trials, cases, symptoms, vaccines, and the efficacy of implemented trials. The results inspired from the compilation of this data in its different forms is exactly what RWE means.[15]

Despite the fact that RWD is highly intelligible for HC professionals and workers, the role of researchers is very important in analyzing RWD, studying its projections,, drawing conclusions, and extracting RWE. A collaboration of professionals who possess knowledge of data analytics and a deeper knowledge in the medical field is required to process RWD for the purpose of understanding how different populations and groups of people contract the virus and the types of symptoms they develop based on various factors including the availability of data

related to viral load, comorbidities, contact tracing, treatment protocols, treatment venues, access to treatment, treatment results, as well as other shaping factors.

The use of RWD in the HC sector during the COVID-19 pandemic is not limited to viral infection, spread, and treatment; it is also vital in providing RWE about the vaccine, its trials, efficacy, and side effects. The fact that some countries managed to get access to the vaccine much earlier than others, from which some have not received any vaccine dose yet, has made early receivers of the vaccine the main source of RWD collected about the vaccine effectiveness, long-term effectiveness, safety, side effects, long-term side effects, and distribution strategies.

2.3.3.4. Blockchain

"Blockchain is a distributed ledger technology that enables users to share trusted and verified information in a decentralized manner. Combined with security and cryptography technology, blockchain can protect the privacy of users who contribute data while also sharing the provenance of the data, enhancing trust". The magical capability of blockchain to promote trust, transparency, and privacy has enabled it to emerge as the best technology-based tool to deliver real-time access to critical information saved and presented in a consistent format from trusted data and data collection sources. Despite the fact that it may sound unrealistic that competing organizations would be willing to share their data with each other and contribute to each other's success, blockchain has indeed proven its effectiveness in promoting the sense of collaboration between competing and

non-competing organizations in the same field due to the auditable sharing platform that blockchain provides while maintaining the full competitive independence and private autonomy of these companies. This advantage of blockchain has highlighted it as a dependable and reliable tool in various healthcare uses and applications especially during COVID-19 pandemic, such as infection spread control, contact tracing, provider credentialing, and patient records-sharing. Such type of cooperation between different healthcare entities has improved the quality of service in all entities, leading to win-win situations for all parties. [16]

3. Methodology

This chapter introduces the approach used in this report in details. Figure 3 is examined in detail and explained step by step for the users of this research. The methodology used in this research starts from literature review, where the challenges facing the healthcare sector; and mainly the healthcare provider as a stakeholder, were identified based on an extensive research done on the topic. The result of the literature review concluded 11 main challenges that were further investigated in phase II using the stakeholder survey. The stakeholder survey has been designed on the basis of the 11 challenges concluded from phase-I in addition to 3 driving factors that impact these challenges. The 11 challenges were included in the survey for the purpose of prioritizing the risks associated with these challenges. On the other hand, the 3 factors were included in the survey to study each one's impact on the challenges, as well as the impact of their correlation with each other. The next step in phase II is the delivery of the survey, which will come out with risk impact results of prioritized risks from the most impactful to the least impactful based on the average score of each challenge in the survey. The top 6 risks in terms of impact were drawn out from the results, identified, defined, explained, and ultimately passed on to be studied in depth in phase III.

After the identification of risks in phase II, the 3 risk drivers included in the survey were statistically analyzed in phase III of the research methodology in terms of their impact on the 11 risks identified in this research. ANOVA was used to investigate the impact of these drivers and the correlation of all 3 factors as well as each two of them in

pairs. The results of the risk drivers analysis has begotten conclusions about the factors to be adjusted in the risk mitigation strategy.

Furthermore, the top 5 impactful risks were added to Risk Registers (RRs) and were assessed based on their impact and likelihood. The combination of impact and likelihood has presented a more effective way to prioritize risk based on its overall risk rating. As a result, the overall results were gathered and summarized in a robust and concise conclusion in the shape of a strategic risk management framework.

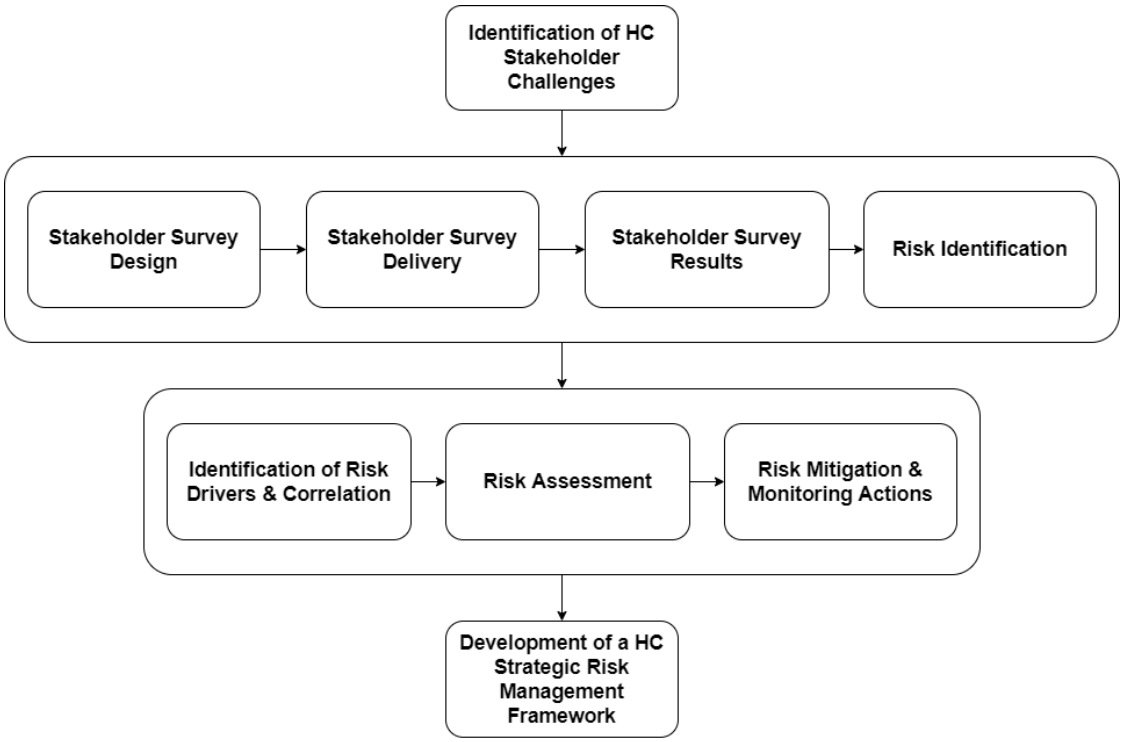


Figure 3 - Research Methodology Flow Diagram

3.1. Identification of Challenges

The challenges presented in this part of the report are the result of the literature review conducted to investigate the potential challenges facing the healthcare sector during the COVID-19 pandemic. The challenges that were considered in the survey were

the top 11 challenges with the highest potential impact on the healthcare providers and management systems; which was identified as the main stakeholder in this report. The investigated challenges have been further analyzed to drive out the main risk associated with each one of these challenges as shown in Table 1.

Table 1 - Stakeholder Challenges

Risk Number	Challenge
1	Covid-19 has led to a lack of adequate capacity to handle the surging patient volume in the healthcare facility
2	Covid-19 has necessitated a real-time redesign of care models for patients.
3	Covid-19 has negatively impacted the physical and mental health of the frontline staff.
4	Covid-19 has led to significant financial losses due to the cancellation of elective procedures and the disruption of routine care.
5	Covid-19 has led to security and data breaches and thus made it difficult to upgrade to electronic health record (HER) systems.
6	Covid-19 has led to a shortage of medical and diagnostic equipment.
7	Covid-19 has led to an over dependence of the care management system on manual processes.
8	The Covid-19 situation has been aggravated by the limited access to data.
9	The Covid-19 situation has been aggravated by the lack of coordination and limited visibility and transparency between stakeholders.
10	The Covid-19 situation has been aggravated by the lack of data standardization and data sharing.
11	Covid-19 has led to difficulties in managing the productivity and quality of remote work delivery.

3.2. Stakeholders Survey

3.2.1. Survey Design

In order to design the survey used in this research, The “Google Forms” platform was adopted to generate the survey link. The survey was divided into two parts; the first part was used to identify the demographic and general characteristics of the respondents, while the second part was used to analyze the challenges faced by the represented HC organization during the COVID-19 pandemic.

The first part consisted of 5 questions that identified the respondent, the HC organization represented, its size, degree of technological development, and the role of the respondent in the HC organization. The second part consisted of 11 questions that provided the main challenges identified in the literature review for the purpose of impact evaluation by the respondents through a 5-point Likert scale (1= strongly disagree to 5= strongly agree). Refer to Appendix (I) for the full survey.

The respondent identification part of the survey included the following five questions:

1- The name of the respondent
2- The role of the respondent in the healthcare organization
3- The name of the healthcare organization
4- The country
5- The size of the healthcare organization

The first two identification questions were to identify the respondent and were not used in the survey analysis. While questions 3 to 5 were used in the survey to study their correlation with the 11 risks in the second part of the survey. The 11 questions in the second part of the survey were meant to investigate the risks that impact the healthcare organizations during the COVID-19 pandemic according to the literature review results. These questions are shown in Table 1 in section 3.1.

3.2.2. Survey Delivery

The survey has been sent to 800 different hospitals in 22 different countries with emphasis on the US, UAE, and Jordan. The surveyed countries included Egypt, Jordan, UAE, and the USA. Healthcare organizations were contacted through medical doctors and other healthcare providers who worked in the healthcare organization during the COVID-19 pandemic. Respondents were asked to answer the 16 questions of the survey and provide their answers objectively based on their work experience at the hospital during the COVID-19 pandemic. The survey to respondents by email and respondents were verified using their personal identification information while providing assurance to respondents that all their records will be kept confidential and published only in aggregate form without names or identifying information. The first survey was filled in on March 1, 2021 and the last survey used for the purpose of this research was filled in on March 12, 2021. The total number of respondents was 97 hospitals in 14 different countries.

3.2.3. Survey Results

The results of the survey were finally collected on March 12, 2021 and analyzed based on the answers of the respondents. The results of questions 1-5 were used to identify the respondent, the facility, the size of the facility, and the role of the respondent in the healthcare organization. Whereas, questions 6-16 were used to identify the main challenges facing the healthcare facility during the COVID-19 pandemic. The challenges with the highest agreement score were prioritized and high-priority challenges were identified. The associated risks were extracted from these challenges and were ranked based on their impact results.

The distribution of the respondents based on their medical roles, technological readiness, country, and HC organization size is shown Table 3, Table 4, Table 5, and Table 6 respectively. While, the ranking of the 11 risks based on results of the survey is as shown in Table 2.

Table 2 - Impact Scores of Stakeholder Challenges

Risk Number	1	2	3	4	5	6	7	8	9	10	11	**Std. Dev.**
Impact	3.598	4.227	4.330	4.412	2.691	3.392	2.918	2.959	3.247	3.361	3.495	0.5865
Std. Dev.	0.982	0.78	0.81	0.79	1.19	1.19	1.14	1.34	1.2	1.23	1.17	

Table 3 - Survey Respondents Classified By Medical Role

Role	**Number**	**Percentage**
Medical Doctor	87	89.69%
Admin	2	2.06%
Other Medical Roles	6	6.19%

Nurse	2	2.06%

Table 4 - Survey Respondents Classified by Technological Readiness

Technological Readiness	Number of Respondents	Percentage
Level 1	1	1.03%
Level 2	8	8.25%
Level 3	15	15.46%
Level 4	38	39.18%
Level 5	31	31.96%

Table 5 - Survey Respondents Classified By Country

Country	Number of Respondents	Percentage
Jordan	21	21.65%
United States	18	18.56%
United Arab Emirates	14	14.43%
Israel	13	13.40%
Egypt	7	7.22%
United Kingdom	6	6.19%
Germany	5	5.15%
Saudi Arabia	3	3.09%
Italy	3	3.09%
Spain	2	2.06%
Mexico	2	2.06%
Canada	1	1.03%
Greece	1	1.03%
Dominican Republic	1	1.03%

Table 6 - Survey Respondents Classified by Healthcare Organization Size

Healthcare Organization Size	Number of Respondents	Percentage
1-50	9	9.3%
50-200	14	14.4%
201-500	15	15.5%
501-1000	17	17.5%
More than 1000	42	43.3%

3.3. Risk Management (RM)

The ultimate goal of the Risk Management process is to come up with a Risk Register (RR) document that details risks induced by COVID-19 on the healthcare sector. A RR records detailed information about each risk to help track and address it whenever it shows up in any healthcare organization during the pandemic or any similar situations in the future. Moreover, the RR contains a description of the risk event, assesses the risk through risk and impact matrices, and suggests monitoring and response actions.

3.3.1. Risk Management Overview

For successful control of the healthcare sector during an event of a pandemic breakout, a Risk Register (RR) should be developed and implemented. The purpose of Risk Management (RM) is to control the process of conducting risk management planning, identification, analysis, response planning, and controlling the risk caused by any of the identified risks associated with the challenges prioritized through the survey.

One of the main goals of this research is to outline a recommended management approach to the healthcare sector risks caused by an event of a pandemic in general and COVID-19 in specific. These risks may be encountered anytime, in any healthcare organization size, and in a situation of any level outbreak severity. To manage risks more effectively, a clear risk management process should be drawn and examples of risks should be provided with suitable assessment.

In order to manage these risks, this report will address the following RM phases:

- Risk Identification
- Risk Drivers
- Risk Assessment
- Response Strategy & Risk Control

3.3.2. Risk Identification

Risk identification is the process of highlighting the risks with the highest priority and defining them in terms of their priority and impact. Furthermore, risk identification is the process of determining *risks* that could potentially prevent a healthcare organization from achieving its main objectives. It is basically focused on documenting and communicating the risk. This can help to set an example for future ventures to avoid falling into the same wrongful path as previous projects.

In order to identify the risks of the COVID-19 pandemic in the HC sector, two identification phases have been conducted. Firstly, the literature review was used to deliver a comprehensive review of the most common challenges facing the various healthcare organizations during the COVID-19 pandemic. The second phase

was conducted to utilize these challenges into a survey collected from 97 healthcare organizations in 14 countries to find out which challenges were perceived by healthcare organizations as the most impactful ones. The results of the survey were used to prioritize these challenges and the risks associated with them.

Table 7 below shows these challenges as well as the risk associated with each challenge. The 5 main risks that were perceived as the most impactful according to the survey were addressed in the next two risk management phases.

Table 7 - Identified Risks Ranked by Impact Score

Impact Order	Risk Number	Challenge	Associated Risk
1	4	Covid-19 has led to significant financial losses due to the cancellation of elective procedures and the disruption of routine care.	Significant financial losses due to the cancellation of elective procedures and the disruption of routine care
2	3	Covid-19 has negatively impacted the physical and mental health of the frontline staff.	Physical and mental health issues of the frontline staff
3	2	Covid-19 has necessitated a real-time redesign of care models for patients.	Disruption in the patient care models and absence of robust real-time care model designs
4	1	Covid-19 has led to a lack of adequate capacity to handle the surging patient volume in the healthcare facility	Overloading healthcare organizations with a huge number of patients, causing a major healthcare crisis when they outnumber the capacity of ICU beds and ventilators available at the facility.
5	11	Covid-19 has led to difficulties in managing the productivity and quality of remote work delivery.	Disruption of healthcare services, major surgical and routine care procedures, and healthcare resource scheduling issues.
6	6	Covid-19 has led to a shortage of medical and diagnostic equipment.	Failure to admit and treat over-flowing patients.

7	10	The Covid-19 situation has been aggravated by the lack of data standardization and data sharing.	Lack of data standardization and data sharing.
8	9	The Covid-19 situation has been aggravated by the lack of coordination and limited visibility and transparency between stakeholders.	Lack of coordination and limited visibility and transparency between stakeholders.
9	8	The Covid-19 situation has been aggravated by the limited access to data.	Limited access to data.
10	7	Covid-19 has led to an over dependence of the care management system on manual processes.	Over dependence of the care management system on manual processes.
11	5	Covid-19 has led to security and data breaches and thus made it difficult to upgrade to electronic health record (HER) systems.	Difficulty to upgrade to electronic health record (HER) systems.

3.3.3. Risk Drivers

Understanding the risks of COVID-19 on the healthcare sector necessitates the understanding of the drivers of these risks. The survey has included 3 main questions that addressed 3 factors that are potentially affecting the impact of each one of the 11 risks under study. These 3 factors included the country, the healthcare facility size, and the technological readiness of the healthcare facility. The impact of these factors on risks was statistically analyzed, and the following results were concluded.

Table 8 - Risk Impact by Country

Country	Risk No.	1	2	3	4	5	6	7	8	9	10	11
Egypt	Risk Impact	3.8571	4.4286	3.4286	4.4286	3.1429	3.5714	2.8571	3.7143	3.5714	3.7143	3.7143
	Risk Priority	4	3	2	1	10	9	11	7	8	6	5
Germany	Risk Impact	4	3.667	4.167	4.167	2.5	2.333	3.333	3	3.667	4	3
	Risk Priority	3	6	2	1	10	11	7	8	5	4	9
Israel	Risk Impact	3.714	4.071	4.071	4.214	3.071	3.786	3.5	3.571	3.857	3.857	3.786
	Risk Priority	8	3	2	1	11	7	10	9	4	5	6
Jordan	Risk Impact	3.714	4.286	4.476	4.667	2.762	3.762	2.857	2.905	3.476	3.714	3.714
	Risk Priority	5	3	2	1	11	4	10	9	8	7	6
UAE	Risk Impact	3.214	4	4.214	4.143	2.357	2.786	2.214	2.357	2.643	2.5	2.786
	Risk Priority	4	3	1	2	10	5	11	9	7	8	6
UK	Risk Impact	3	4.167	4.667	4.5	2.333	2.5	2.833	2.167	3	2.667	3.167
	Risk Priority	6	3	1	2	10	9	7	11	5	8	4
USA	Risk Impact	3.611	4.5	4.556	4.444	2.389	3.611	2.833	3.278	3	3.333	3.556
	Risk Priority	4	2	1	3	11	5	10	8	9	7	6

Table 8 above shows the results of the survey classified based on the country. Risk 4 has had the highest impact in Egypt, Germany, Israel, and Jordan, while risk 3 has had the highest impact in the UAE, the UK, and the US. This conclusion shows that despite the fact that risk 3 has had the highest overall impact on all respondents, it still had more impact in particular countries than the others. As mentioned earlier in the report, countries with less than 5 survey respondents were excluded from the classified statistical analysis to minimize bias..

Table 9 below shows the classification of risks based on the size of the healthcare facility. It is evident from Table 9 that the impact of the risk was driven differently by the size of the healthcare facility. Therefore, healthcare facilities with size A, B, and E have identified risk 4 as the most impactful, while healthcare facilities of size C and C identified risk 3 as the most impactful.

Table 9 - Risk Impact by Healthcare Organization Size

	Size	Count	Risk No.	1	2	3	4	5	6	7	8	9	10	11
A	1-50	9	Risk Impact	3.556	4.222	3.778	4.333	2.556	2.667	2.778	2.889	3.111	3.111	3.000
			Risk Priority	4	2	3	1	11	10	9	8	6	5	7
B	51-200	14	Risk Impact	3.071	3.857	4.071	4.500	3.071	3.214	2.643	2.643	3.214	3.214	3.643
			Risk Priority	9	3	2	1	8	7	10	11	6	5	4
C	201-500	15	Risk Impact	3.667	4.333	4.733	4.400	3.133	3.667	3.533	3.400	3.667	3.400	3.667
			Risk Priority	4	3	1	2	11	7	8	9	6	10	5
D	501-1000	17	Risk Impact	3.824	4.353	4.471	4.294	2.529	3.529	3.000	3.294	3.353	3.706	3.647
			Risk Priority	4	2	1	3	11	7	10	9	8	5	6
E	More than 1000	42	Risk Impact	3.667	4.262	4.333	4.452	2.500	3.452	2.786	2.786	3.095	3.310	3.429
			Risk Priority	4	3	2	1	11	5	10	9	8	7	6

In Table 10 shown below, the classification of the risk results is conducted based on the technological readiness of the healthcare facility. Only one healthcare facility has identified itself technologically unready while all other facilities have identified themselves as technologically ready with varying levels as shown in the count in Table 10 below. Therefore, only healthcare facilities with technological readiness levels between 2 to 5 were considered.

Table 10 - Risk Impact by the Technological Readiness of the Healthcare Organization

Technological Readiness	Count	Risk No.	1	2	3	4	5	6	7	8	9	10	11
1	1	Risk Impact	5	5	5	5	4	4	3	5	5	5	5
		Risk Priority	1	1	1	1	2	2	3	1	1	1	1
2	8	Risk Impact	3.25	4	4.375	4.375	3.25	3.375	2.5	3	3.875	3.625	3.875
		Risk Priority	9	3	2	1	8	7	11	10	4	6	5
3	15	Risk Impact	3.933	4.133	4.000	4.600	2.867	3.667	3.400	3.533	3.533	3.800	3.267
		Risk Priority	4	2	3	1	11	6	9	8	7	5	10
4	40	Risk Impact	3.6	4.175	4.25	4.3	2.6	3.15	2.825	2.625	3	3.025	3.525
		Risk Priority	4	3	2	1	11	6	9	10	8	7	5
5	33	Risk Impact	3.485	4.364	4.545	4.455	2.545	3.545	2.909	3.030	3.212	3.455	3.424
		Risk Priority	5	3	1	2	11	4	10	9	8	6	7

Table 10 above show that healthcare facilities with technological readiness level 2, 3, and 4 have been impacted the most by risk 4 (financial losses), while healthcare facilities with the highest technological readiness level (5) of the healthcare facility were impacted

more by the risk of physical and mental health issues of the healthcare frontline staff (risk 3).

Furthermore, the three factors were analyzed statistically using Minitab to study their impact on each one of the 11 risks and to investigate if any one of them has a significant effect on any of these risks. Therefore, an ANOVA test was conducted for each one of the risks that were used in Minitab as responses, while the three risk drivers were used as factors. The interaction of the three drivers was also used to measure the interchanging impact of these risk drivers on the 11 risks in study.

A 90% confidence level was used in the analysis and led to the the result that 3 of the 11 risks identified in the healthcare sector are driven by one or more of the factors investigated in the survey. These 3 risks were risk 3, risk 6, and risk 11:

1. Risk 3: Covid-19 has negatively impacted the physical and mental health of the frontline staff.

   This risk was significantly impacted by the size of the healthcare facility. This is evident in the ANOVA Table 11 shown below, whereby the P-value for the "Hospital Size" factor is 0.081 and that's less than the value of alpha (0.1).

   The pairwise comparison in Table 12 highlights the significant impact of the size of the healthcare facility on risk 3, and highlights the fact that midsize facilities (Size C - 201-500) were the most affected by risk 3 while small size facilities (Size A & B - 0-200) and large size facilities (Size E - More than 1000) were the least affected by risk 3.

Table 11 - Risk 3 Drivers ANOVA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Country	13	10.111	0.7778	1.20	0.296
Hospital Size	4	5.615	1.4037	2.17	0.081
Tech Dev	4	2.768	0.6921	1.07	0.378
Error	75	48.598	0.6480		
Lack-of-Fit	37	18.217	0.4923	0.62	0.928
Pure Error	38	30.381	0.7995		
Total	96	69.443			

Table 12 - Risk 3 Drivers Grouping Using Fisher

Grouping Information Using Fisher LSD Method and 90% Confidence

Hospital Size	N	Mean	Grouping	
C	15	4.93216	A	
D	17	4.52407	A	B
E	42	4.43205		B
B	14	4.07932		B
A	9	4.05505		B

Means that do not share a letter are significantly different.

2. Risk 6: Covid-19 has led to a shortage of medical and diagnostic equipment.

   This risk was significantly impacted by the country, given that the P-value of the "Country" factor is 0.006 and that's significantly less than the value of alpha (0.1).

Table 13 - Risk 6 Drivers ANOVA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Country	13	37.189	2.8607	2.53	0.006
Hospital Size	4	5.879	1.4698	1.30	0.278
Tech Dev	4	3.464	0.8660	0.77	0.551
Error	75	84.788	1.1305		
Lack-of-Fit	37	39.076	1.0561	0.88	0.653
Pure Error	38	45.712	1.2029		
Total	96	133.113			

Table 14 below shows the pairwise comparison between the countries in the study, and highlights the significant difference between the impact of risk 6 (Medical and diagnostic equipment shortage) in countries like Jordan and Egypt who have been most impacted by this risk, and the UAE and the UK who have been least impacted by this risk.

Table 14 - Risk 6 Drivers Grouping Using Fisher

Grouping Information Using Fisher LSD Method and 90% Confidence

Country	N	Mean	Grouping
S	2	4.93308	A
M	2	4.21942	A B
D	1	4.14324	A B C D
C	1	3.88667	A B C D E
J	21	3.81039	A B
E	7	3.79457	A B
IS	13	3.57186	A B
IT	3	3.30553	A B C D E
US	18	3.09243	B C F
UAE	14	2.67422	C D E F G
G	5	2.21228	C D E F G
UK	6	2.15343	D E G
SA	3	1.91194	E G
GR	1	1.01240	F G

Means that do not share a letter are significantly different.

3. Risk 11: Covid-19 has led to difficulties in managing the productivity and quality of remote work delivery.

   This risk was significantly impacted by both the country and the technological readiness of the healthcare facility. This is evident in the ANOVA shown in Table 15 below with P-values for both factors below the 0.1 value of alpha.

Table 15 - Risk 11 Drivers ANOVA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Country	13	28.452	2.1886	1.83	0.054
Hospital Size	4	7.135	1.7839	1.49	0.213
Tech Dev	4	11.141	2.7853	2.33	0.064
Error	75	89.721	1.1963		
Lack-of-Fit	37	31.209	0.8435	0.55	0.965
Pure Error	38	58.512	1.5398		
Total	96	126.247			

Table 16 below shows the different impact of risk 11 on the healthcare facility based on the country. The pairwise comparison in Table 16 shows the significant difference between the UK and the UAE on one hand, and Jordan on the other. Healthcare facilities in Jordan has been the most impacted by risk 11, while healthcare facilities in the UK and the UAE have been the least impacted by risk 11.

Table 16 - Risk 11 Drivers Grouping Using Fisher

Grouping Information Using Fisher LSD Method and 90% Confidence

Country	N	Mean	Grouping
GR	1	5.82835	A
C	1	5.13657	A B
S	2	4.83729	A B
E	7	4.50300	A
J	21	4.11600	A B C
M	2	4.02579	A B C D E
IT	3	3.86258	A B C D E
IS	13	3.79145	A B C D
US	18	3.33141	B C D E
G	5	2.93804	D E F
SA	3	2.90397	C D E F
UK	6	2.86484	D E F
UAE	14	2.67877	E F
D	1	1.31461	F

Means that do not share a letter are significantly different.

Another important driver of risk 11 is the technological readiness of the healthcare facility. Excluding the effect of healthcare facilities with the lowest level of technological readiness due to the negligible sample size, the pairwise comparison shown in Table 16 below shows the significant difference in the impact of risk 11 on healthcare facilities with the highest technological readiness in comparison to those with lower technological readiness. Which suggests that healthcare facilities with higher technological development and readiness have encountered more difficulties in managing and running their remote work delivery than less technologically developed healthcare facilities. Despite the fact that this may seem contradicting to common sense, it however addresses the fact that less technologically-advanced facilities depended less on remote work delivery before the breakout of the pandemic and thus no disruption of remote work has happened and therefore such facilities have not experienced any significant impact.

It is of high importance to underline the fact that the results of the statistical analysis were only meant to identify the significant impact of the 3 risk drivers on the 11 identified risks. Nevertheless, that does not contradict the fact that any one of the factors could have had its own effect on other risks but has not been identified as a significant impact. Table 17 shows the impact of each factor on each one of the 11 identified risks.

Table 17 - Factors affecting Healthcare Risks

	Risks										
Factor	**Risk 1**	**Risk 2**	**Risk 3**	**Risk 4**	**Risk 5**	**Risk 6**	**Risk 7**	**Risk 8**	**Risk 9**	**Risk 10**	**Risk 11**
Technological Readiness (TR)											**X**
Healthcare Organization Size (HOS)			**X**								
Country (C)						**X**					**X**
TR*HOS											
TR*C											
HOS*C											
TR*HOS*C											

3.3.4. Risk Assessment

Risk assessment is a systematic approach that is used to evaluate potential risks related to healthcare organizations in case of a pandemic breakout. Before the process of risk assessment is performed, the associated risks should first be recognized and well defined. Risk identification and assessment are best managed using the Risk Register (RR) as a tool that lends discipline to the process.

The risk assessment process can start with the step of developing a list of risk assessment criteria that is later implemented during the breakout of a pandemic. The basis of risk assessment is built over the impact (consequence) and likelihood (probability) of the risk, which together form the 'risk rating'. Upon assessment, risks are ranked based on their impact and likelihood to be further quantitatively analyzed. Evaluation of the importance and priority of each risk is typically analyzed by the probability and impact assessment, and then converted to the lookup table – risk assessment matrix. Such a matrix determines combinations of impact and probability that lead to the risk ratings as low, moderate, or high priority. Figure 4 illustrates the risk assessment flow process.

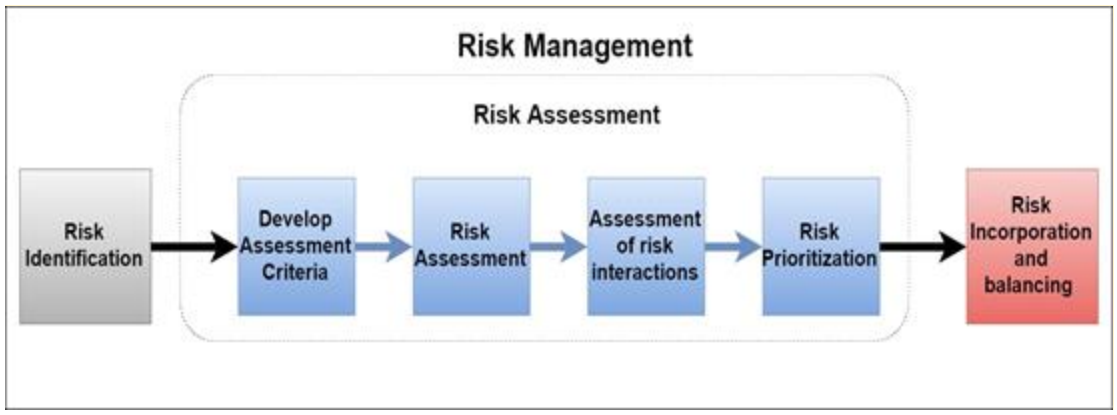


Figure 4 - Risk Assessment Flow Diagram

3.3.4.1. Probability & Likelihood

Probability is the possibility that a particular event will happen. There are different ways to express probability including qualitative terms (e.g., frequent, likely, possible, unlikely, rare), a frequency, or a percent probability (10%, 20, 50%,…). When numerical values are used, whether a percentage or frequency, the relevant time period should be indicated (e.g., monthly frequency) or the more

relative probability over the life of the project. Although the value can be expressed in various ways, but in this research it will be assigned a value as defined in Table 18 below.

Table 18 - Probability of Occurrence Scale

Number	Level
1	**Highly Unlikely**
2	**Unlikely**
3	**Likely**
4	**Highly Likely**
5	**Near Certainty**

3.3.4.2. Impact (Consequence)

In risk assessment, impact (or consequence) refers to the extent to which a risk event might affect the project. Impact assessment criteria may include: financial, reputational, regulatory, health, safety, security, environmental, employee, customer, and operational impacts. In this Risk Management analysis, the impacts are categorized as either technical, schedule or cost impact. Table 16 indicates the assigned impact levels. In addition, the impact level of each risk is identified by the impact level result from the survey. Therefore, a risk with an impact level of 4, will be classified as a major risk, while a risk with an impact of 2 will be identified as a minor risk.

Table 19 - Potential Risk Impact Scale

Symbol	Level
A	**Minimal**
B	**Minor**
C	**Moderate**
D	**Major**
E	**Severe**

3.3.4.3. Risk Matrix

A five by five grid with impact along the x-axis and likelihood on the y-axis is used to indicate the risk ratings in this research. Figure 5 identifies the ratings used in this report.

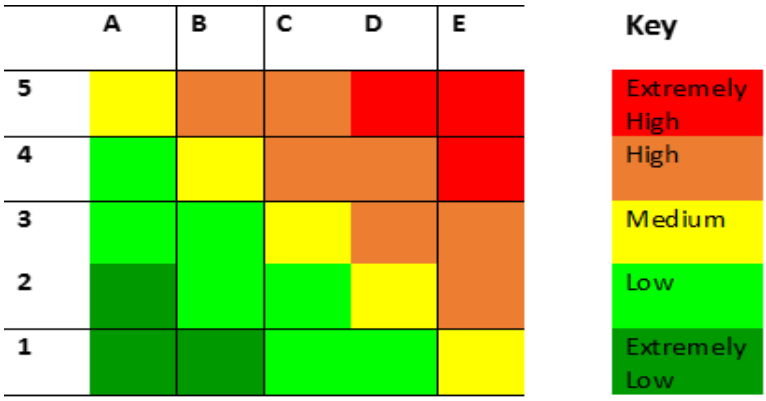


Figure 5 - Risk Matrix

3.3.5. Risk Control & Response Strategy

In this phase of risk management, risk registers are created to combine the findings of the previous two sections in Risk Registers alongside the control actions,

mitigation actions, and response strategy for each one of these risks identified and assessed in the previous phases.

3.3.6. Risk Registers

Risk Registers (RR) were prepared for the 5 risks with the highest impact to assess these risks in terms of their impact and likelihood. Risk impact is measured on a scale from A to E, with “A” representing the most impactful risk and “E” representing the risk with the lowest impact. Whereas, the risk likelihood is measured on a 5-point Likert scale with “1” having the least likelihood and “5” with the highest likelihood.

The RRs for the five most impactful risks are shown in Tables 20, 21, 22, 23, 24, and 25 shown respectively based on the order of their impact.

Table 20 - Risk Register 4

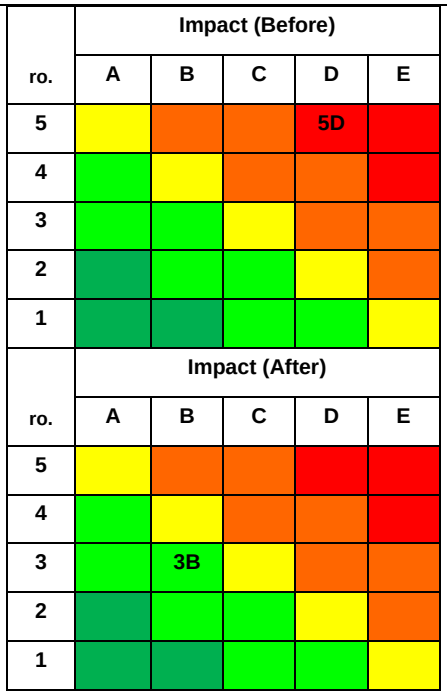
Risk Number : C04	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**

Risk Title: Financial Losses		**Date Identified:** March/08/2021
Organization/Title :	**SSCRI :**	**Contact info. :** mak1123@rit.edu

Risk description

Statement of Risk: The breakout of the pandemic has pushed governments to impose countrywide lockdowns to minimize interaction of individuals in public places ad closed areas. These lockdowns as well as the associated fear from social gatherings and interactions have led to a major drop in the number of patients visiting healthcare facilities for routine care and elective procedures. The no show situations whether by patient choice or forced by lockdown circumstances have led to the cancellation of many elective procedures and a disruption of routine care. These disruptions and cancellations have caused serious financial losses for health organizations during the COVID-19 pandemic.

	Monitoring Action			
Monitoring /Surveillance	1-Remodeling of queues and schedules using automatic (smart) scheduling systems utilizing OR techniques.			
	2-The design of a smart patient appointment-scheduling interface (Mobile APP) updated through medical staff real-time availability and facility disinfection database.			
	3-Using telehealth technologies that enable medical doctors to perform procedures distantly while minimizing direct interaction with patients and ensuring minimum viral infection.			
	4-Integrating robotic assistants to minimize the interaction of patients with healthcare providers as well as other patients in the same healthcare facility			



<Risk Assessment Matrix>

Probability:	Near Certainty	**Basis:**
Impact /Consequence	Major damage	**Basis:**
Risk rating	5D	Extremely Low [ ], Low [ ], Medium [ ], High [ ], Extremely High [√]

Comments

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

Table 21 - Risk Register 3

Risk Number : C03	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**
Risk Title: Impact on physical and mental health				**Date Identified:** March/08/2021	
Organization/Title :		**SSCRI :**		**Contact info. :** mak1123@rit.edu	

Risk description

Statement of Risk: Hospitals and clinics have to ensure an adequate supply of Personal Protective Equipment (PPE) for their staff. In addition to the risk of contracting the virus, frontline staff have to cope with tremendous mental stress, which some may find unbearable. There have been anecdotal reports of frontline staff dying by suicide.

	Monitoring Action			
Monitoring /Surveillance	Use of telepresence robots with the collaboration of nursing stuff to screen patients, thus reducing the risk to HC staff.			
	HC providers build social media medical neighborhoods and awareness campaigns to assist in self-care.			
	Scheduling of regular visual appointments with a psychiatrist/therapist to help improve the mental health of the frontline staff.			
	Using telehealth technologies that enable medical frontline staff to perform their tasks distantly from home to reduce the hospital stress ambience.			

Pro.	Impact (Before) A	B	C	D	E
5					
4				4D	
3					
2					
1					

Pro.	Impact (After) A	B	C	D	E
5					
4					
3					
2		2B			
1					

<Risk Assessment Matrix>

Probability:	Highly Likely	**Basis:**
Impact /Consequence	Major damage	**Basis:**
Risk rating	4D	Extremely Low [ ], Low [ ], Medium [ ], High [√], Extremely High [ ]

Comments

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

Table 22 - Risk Register 2

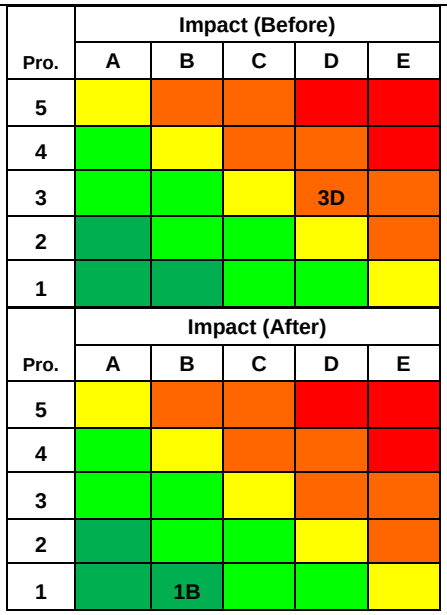
Risk Number : C02	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**

Risk Title: The necessity of real-time redesign of care models		**Date Identified:** March/08/2021
Organization/Title :	**SSCRI :**	**Contact info. :** mak1123@rit.edu

Risk description

Statement of Risk: Given the highly contagious nature and severity of the infection, it is necessary for physicians, nurses, and other clinicians to discover the appropriate care model and room design. The inappropriate modeling of care models may lead to the aggravation of the infection rates and spread of the virus.

	Monitoring Action			
Monitoring /Surveillance	1-Remodeling of queues and schedules using automatic (smart) scheduling systems utilizing OR techniques.			
	2-The development of a facility layout capacity-maximizing software with the purpose of providing an appropriate care model in the most suitable room design.			
	3-Using block chain-based collective real-time care-model design experience platform to facilitate the access of any healthcare facility to the database provided by a wide cross-country hospital network.			
	4-The redesign of a facility layout capacity-maximizing software using the real-time data extracted from the block chain-based collective real-time care-model design experience platform.			



<Risk Assessment Matrix>

Probability:	Highly Likely	**Basis:**
Impact /Consequence	Major damage	**Basis:**
Risk rating	4D	Extremely Low [ ], Low [ ], Medium [ ], High [√], Extremely High [ ]

Comments

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

Table 23 - Risk Register 1

Risk Number : C01	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**

Risk Title: Lack of Adequate Patient Capacity		**Date Identified:** March/08/2021
Organization/Title :	**SSCRI :**	**Contact info. :** mak1123@rit.edu

Risk description

Statement of Risk: The lack of adequate capacity to handle the surging patient volume can overload hospitals with a huge number of patients, which can cause a major healthcare crisis in case they outnumber the capacity of ICU beds and ventilators available at hospitals, which may ultimately lead to a major crisis.

	Monitoring Action			
Monitoring /Surveillance	The development of a facility layout capacity-maximizing software with the purpose of providing an appropriate care model in the most suitable room design.			
	Using block chain-based collective real-time patient capacity reporting platform connected with a patient interface to navigate patients to the nearest healthcare facility with available patient capacity.			
	Remodeling of queues and schedules using automatic (smart) scheduling systems utilizing OR techniques.			
	Using telehealth technologies that enable medical doctors to perform diagnostic and consultancy procedures distantly to prioritize patients based on critical conditions and thus reduce the number of patient visits.			

Pro.	Impact (Before) A	B	C	D	E
5					
4					
3				3D	
2					
1					

Pro.	Impact A	B	C	D	E
5					
4					
3					
2					
1		1B			

<Risk Assessment Matrix>

Probability:	Likely	**Basis:**
Impact /Consequence	Major damage	**Basis:**
Risk rating	3D	Extremely Low [ ], Low [ ], Medium [ ], High [√], Extremely High [ ]

Comments

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

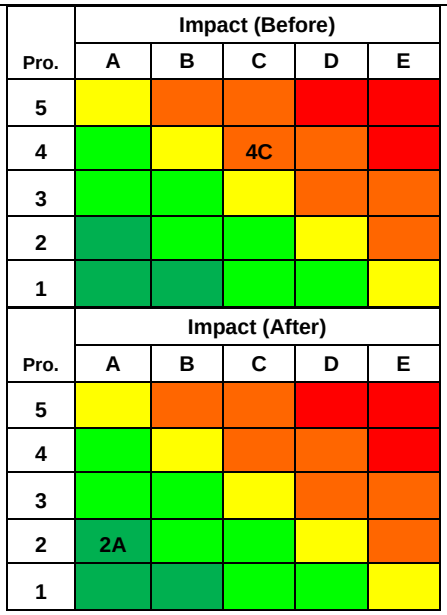
Table 24 - Risk Register 11

Risk Number : C011	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**
Risk Title: Disruption of Remote Work Delivery				**Date Identified:** March/08/2021	
Organization/Title :			**SSCRI :**	**Contact info. :** mak1123@rit.edu	

Risk description

Statement of Risk: COVID -19 has led to difficulties in managing the productivity and quality of remote work delivery, especially at technologically developed healthcare facilities that have heavily depended on remote work delivery and telehealth procedures before the COVID-19 pandemic. Such difficulties have led to disruption of healthcare services, major surgical and routine care procedures, and healthcare resource scheduling issues.

	Monitoring Action			
Monitoring /Surveillance	1-The design of a smart scheduling software to optimize the utilization of the availability of medical doctors for remote medical procedures and remote work delivery.			
	2-The development of a smart medical diagnostic software to expedite the work of on-call medical staff in order to increase the number of designated medical staff remote-working hours.			
	3-Data as a Platform (DaaP) can be used to provide data, which is harnessed to create personalized treatment plans for patients and boost payer/provider relationships.			
	4-HC providers utilize an AI-based online screening and triage tools to offer patients improved access to care, regardless of their geographical location.			



<Risk Assessment Matrix>

Probability:	Likely	**Basis:**
Impact /Consequence	Moderate damage	**Basis:**
Risk rating	4C	Extremely Low [ ], Low [ ], Medium [ ], High [√], Extremely High [ ]

C o m m e n t s

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

Table 25 - Risk Register 6

Risk Number : C06	**Category :** C	**Revision :** 0A	**Last updated :** March/08/2021	**Status:** Open	**Closed date :**
Risk Title: Shortage of Medical and Diagnostic Equipment				**Date Identified:** March/08/2021	
Organization/Title :			**SSCRI :**	**Contact info. :** mak1123@rit.edu	

Risk description

Statement of Risk: The breakout of the COVID-19 pandemic has led to an overflow of hospitals with surging number of patients who outnumber the beds and ICU rooms. This surge has led to the over-utilization of medical and diagnostic equipment at overloaded healthcare facilities. This overutilization of equipment has caused a prominent shortage that necessitated more equipment and has led to failure in admitting and treating over-flowing patients.

	Monitoring Action			
Monitoring /Surveillance	1-Using block chain-based collective claim-sharing platforms, HC facilities can continuously update suppliers with latest products requirements, specifications and ensure timely equipment delivery.			
	2-Using block chain-based collective real-time patient capacity reporting platform connected with a patient interface to navigate patients to the nearest healthcare facility with available patient capacity.			
	3-Using block chain-based collective real-time equipment inventory level database in a countrywide hospital network that enables hospitals to exchange and rent medical and diagnostic equipment based on their surging need and availability.			

Pro.	Impact (Before) A	B	C	D	E
5					
4					
3			3C		
2					
1					

Pro.	Impact (After) A	B	C	D	E
5					
4					
3					
2	2A				
1					

<Risk Assessment Matrix>

Probability:	Likely	**Basis:**
Impact /Consequence	Moderate damage	**Basis:**
Risk rating	3C	Extremely Low [ ], Low [ ], Medium [√], High [ ], Extremely High [ ]

Comments

Evaluation Comments:

Prepared by / Date	**Reviewed by / Date**	**Owner Acknowledgement / Date**
Mohammad Khasawneh		

4. Results & Conclusion

In this research, several aspects of healthcare challenges were investigated to conclude major risks in the healthcare industry during the COVID-19 pandemic. These risks were prioritized based on their impact on the main stakeholder in the healthcare sector. Given the fact that the main stakeholder considered in this research was the healthcare organizations and management systems, this research has been given the flexibility to cover a wider variety of the aspects of the sector, as well as the challenges.

The risk identification and prioritization processes in this survey were conducted using a stakeholder-based survey that has been distributed to several healthcare organizations in 22 different countries around the world. The survey results were collected after receiving the 100^{th} survey response given the limited research timeframe and the sufficiency of the data sample in minimizing bias. All 11 risks in study were analyzed in terms of the impact of 3 external factors called risk drivers; which include the country, the size of the healthcare organization, and the technological readiness. These drivers have been proven to have impact on some of these risks but not all of them. The correlation between these drivers as well as the impact of this correlation have been investigated to see how different combinations of these drivers affect the risks in the healthcare sector.

[The results of this research have shown that the main risks impacted by these factors were risks 3,6, and 11. The factors impacting the risks were different from one another while some risks were impacted by more than one factor at a time. The impact of these factors over different risks has been justified in this research showing the reasoning behind the impact of each risk driver. The importance of risk drivers stems out from the

fact that these drivers can be used as a starting point to generate solutions and ideas based on the concept of attacking the cause of the problem instead of the problem itself.

The 6 highest priority risks were moved into risk registers for further evaluation done through risk assessment techniques. Risk assessment was done on the basis of both the risk impact attained from the survey and the risk likelihood attained through literature review and observation. The process of risk assessment was a powerful tool to that segmented and detailed each risk and hence facilitated the understanding of these risks for the purpose of counteracting to these risks using risk mitigation and monitoring actions and solutions. The trademark of this research was that digital transformation tools were the base for risk mitigation and monitoring solutions and actions. The use of digital transformation technologies as a base has paved the way for more innovative solutions and actions to take part of the risk registers used in the risk management study.

As a conclusion, the framework developed in this research has helped in reducing the impact and the likelihood of each one the identified risks to lower levels in the risk assessment matrix, and hence reduced the rank of these risks. Moreover, the implementation of the mitigation and monitoring actions enacted in this research will reduce the average risk of the 6 high-priority risks surveyed by 38.3% from around 3D to around 2B as shown in Table 26, which represents a considerable improvement in the readiness of healthcare organizations to face these risks for future applications. The strategic risk mitigation framework concluded in this research is shown in Figure **6**.

Table 26 - Risk Rank Improvement

Risk Number	Before	After	Improvement
Risk 4	5D	3B	40%
Risk 3	4D	2B	40%
Risk 2	3D	1B	40%
Risk 3	3D	1B	40%
Risk 11	4C	2A	40%
Risk 6	3C	2A	30%
Average	3D	2B	38.3%

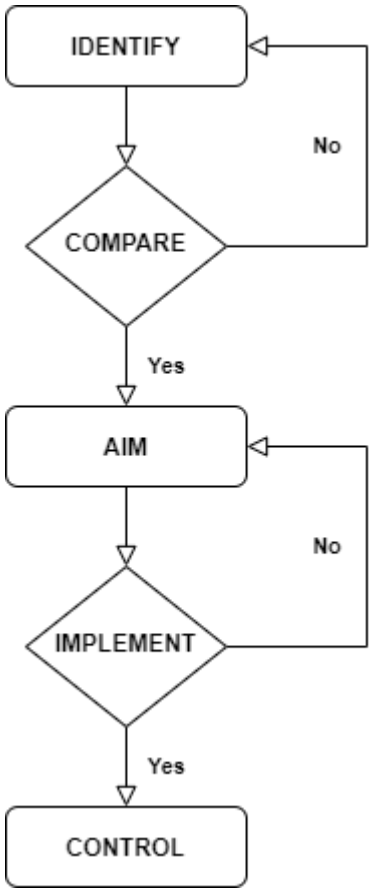


Figure 6 - Risk Management Framework

For healthcare providers management systems willing to mitigate, monitor, and even proactively encounter the risks posed by COVID-19 or any other similar situation, following the risk management framework depicted in Figure 6 can provide a step-by-step approach as explained below:

1) **IDENTIFY:**

In this phase of the framework, challenges at the healthcare organization are identified and the associated risks are estimated. The healthcare organization has to investigate its main challenges in relation to the effect of the pandemic on the organization and the management system.

2) **COMPARE:**

In the COMPARE phase, the healthcare organization can compare its challenges with the list of identified challenges in this report. Mutual challenges have to be highlighted and addressed accordingly in the next AIM phase. If the challenges of the organization are entirely different from the challenges identified in the report, then the organization should compare its associated risks with the risks identified in the report. If no mutual risks are found, then the identification phase has to be repeated to reinvestigate the challenges of the healthcare organization until common challenges are highlighted and the associated risks are identified.

3) **AIM:**

In this phase, the healthcare organization has to aim for a particular risk rank by specifying a target for an achievable risk rank it wishes to achieve. This phase is very important as it helps in identifying the type of monitoring and mitigating actions to be enacted in the next phase.

4) **IMPLEMENT**:

In this phase, monitoring and mitigating actions are identified based on the risk rank planned in the previous AIM phase. Given the fact that each monitoring/mitigating action is able to achieve a certain level of improvement on the rank of the risk, the magnitude of desired improvement by the healthcare organization will identify the required monitoring and mitigation actions to be used. If the healthcare organization finds that the improvement planned in the framework has not been achieved as planned, the healthcare organization should go back to the previous AIM phase and reconsider the desired risk rank so that different risk monitoring and mitigation actions can be identified and implemented accordingly.

5) **CONTROL**:

The last phase of the risk management framework is the CONTROL phase, which is meant to measure the effectiveness of the monitoring actions implemented in the previous phase. This phase is conducted by the healthcare organization using internal measures and KPIs that show the amount of improvement achieved using the risk management framework designed in this report. Another goal of this phase is to maintain the improvement achieved by this risk management framework and ensure the fulfillment of the strategic goals of the risk management process.

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APPENDEX I

Risk Management Through Digital Transformation in the Healthcare Sector During The COVID-19 Pandemic

- This survey is delivered as part of a research project conducted at Rochester Institute of Technology.
- The research is aimed at studying the challenges faced by the healthcare sector during the COVID-19 pandemic.
- This survey has been approved by the Institutional Review Ethics Board (IREB) at RIT.
- Your answers will be recorded in written format without your name or any identifying information.
- All records will be kept confidential and published only in aggregate form without names or identifying information.
- Please fill in this survey before March 18, 2021.

Should you have any inquiries about this survey, please contact us at mak1123@rit.edu

* Required

What is your name? (All records will be kept confidential and published only in aggregate form without names or identifying information). *

Your answer

What is your role in the healthcare organization your represent? *

- ◯ Medical Doctor
- ◯ Nurse
- ◯ Admin
- ◯ Other medical roles

What is the name of the healthcare organization/hospital your represent? (All records will be kept confidential and published only in aggregate form without names or identifying information). *

Your answer

Where is your healthcare facility located? *

Choose

What is the size of your healthcare facility (number of healthcare staff)? *

- ◯ 1-50
- ◯ 50-200
- ◯ 201-500
- ◯ 501-1000
- ◯ More than 1000

On a scale of 1 to 5, how technologically developed do you think your healthcare provider is? *

	1	2	3	4	5	
Not Developed	◯	◯	◯	◯	◯	Very Well Developed

Covid-19 has led to a lack of adequate capacity to handle the surging patient volume in the healthcare facility *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has necessitated a real-time redesign of care models for patients. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has negatively impacted the physical and mental health of the frontline staff. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has led to significant financial losses due to the cancellation of elective procedures and the disruption of routine care. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has led to security and data breaches and thus made it difficult to upgrade to electronic health record (HER) systems. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has led to a shortage of medical and diagnostic equipment. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has led to an over dependence of the care management system on manual processes *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The Covid-19 situation has been aggravated by the limited access to data. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The Covid-19 situation has been aggravated by the lack of coordination and limited visibility and transparency between stakeholders. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The Covid-19 situation has been aggravated by the lack of data standardization and data sharing. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Covid-19 has led to difficulties in managing the productivity and quality of remote work delivery. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Submit