Peer Review File

Reviewer A

Comment: This manuscript tries to take on too much at once (bites off more than it can chew) and therefore, does not make for coherent conceptual paper.

Response: Thank you for your thoughtful comments. In this paper, we aimed to emphasize that the U.S. health system is linked with private healthcare system and every risk analysis is linked with the cost. The U.S. healthcare system is unique and totally different from any other nation in the world. It's a very lean based system where every penny earned is billed for. Page 3 and page 4 is the literature review about the U.S. healthcare system. The root cause analysis of fixing the U.S. healthcare system lies in understanding the hospital flow system (start to finish) in a facility and its linkage with all the insurances authorizations. Page 5 talks about the U.S. health management historical trend. Historically (i.e., pre-COVID-19 era), the management of hospitals were attracted towards profit that is divided among stakeholders, marketing or hiring expensive physicians or surgeon to fulfill the demand, however the recent experience of COVID-19 pandemic has exposed where the cost needs to be spent in the next 10 to 20 years. The need for engineering concepts in healthcare, the need for more nurses to patient ratio and doctor to patient ratio (infectious disease/intensivist MDs). If the audience have no conceptual view of the U.S. healthcare system and have not experienced this kind of system, the manuscript will be a lot of information for them to take on.

Comment: A coherent conceptual paper (that seeks to apply or develop a framework to address a problem), needs to begin with a clearly defined problem statement. For example, to address the twin challenges of patient safety and staff safety while providing care to a growing volume of patients during COVID-19, hospitals/healthcare organizations need to be resilient. In this context, the Organizational Resilience framework could be used to gain insights into strategies for HCOs to adapt to rapid change.

This paper however, reads like an informal discussion about everything that went wrong with the US healthcare system during COVID-19, and how such a complex set of systemic challenges could be addressed all at once.

Response: Systematic challenges were always addressed in the U.S. health system even before the COVID-19 era by different scholars. Our paper just focusses on what the U.S healthcare system is, what operational challenges the U.S. hospitals face, what operational challenges it faces if unforeseen scenarios happens, what operational challenge were addressed already, and most importantly as we have a private hospital setup at each community in the U.S. so how is the management of each hospital facility able to understand it on a bigger horizon of patient centric attitude rather than a profit-based concept. We have state-of-the-art machines and technology; however, we lack people to support that technology and often work 24/7 to fulfill the need. For example; a physician taking care of a patient ordering a normal blood test, by the time that blood is drawn and reach the laboratory and before even the lab can work on that blood type, we are missing skilled people to complete the whole process, not even all the laboratories in each hospital all over the U.S. are fully equipped, tests are flown and drove to in some cases miles away where they can be resulted. The timeline of different test analyses does affect the physicians' decision-making approach.

Historical references are made about the U.S. healthcare system in the Introduction/Background pages 2,3, and 4. This was followed by the root cause analysis starting to understand a healthcare facility flow and understanding the emergency severity level which leads to recommending three key *frameworks* (viz., health surveillance, workforce, and modular facilities) that would be helpful in creating a balance within the healthcare industry's daily operation which is the paramount need of the "new normal" and sustainability.

Comment: This is too broad a scope for a coherent conceptual paper. What is the unit of analysis here?

Response: Agreed – our paper has broad scope. The unit of analysis here is the risk analysis of the U.S. hospitals that faces operational challenges on daily basis when unforeseen happen, it's not just recent COVID-19 pandemic, a simple emergency room can develop an unforeseen scenario at any given time. Risk analysis models in health system cannot be determined but they can be predicted with some level of confidence interval because the data source is stochastic.

Comment: Who is the target audience?

Response: The U.S. healthcare is mostly private funded care; hence the target audience is hospital management, healthcare facility managements, and stakeholders that supports the individual hospitals. For example, it can be local community/non-profit organizations, board members of hospitals, hospital associations all over the U.S., the

U.S. Government, States, District and/or County managements involved in recommending/accepting such health facility policies.

Comment: If the healthcare system as a whole failed to respond to the unforeseen scenario of COVID-19, who is responsible? State or federal government? Policymakers?

Response: Unforeseen scenarios always existed and would always keep their growing existence, however when the unforeseen happens it is the operational need that are thinned because no one have planned proactively to predict that stochastic approach.

The State or Government at that stage take the responsibility (when unforeseen develops such as the current pandemic, to maintain the district/county management) to own it and control the ongoing situation; however, still it falls at each hospital facility management as to what resources the hospital management had in order to support the operational need (example: equipment, type of doctors/nurses/laboratory staff in the community, and lab equipment to support that operation).

Hospital and healthcare systems in the U.S. require industrial and data analytic engineers' help in the policymaking. The State and Government need to understand the conceptual risk model and should accept or reject the risk based on the level of verification and validation. The State and Government recommendation obviously affects the hospitals policies.

Comment: Healthcare organizations – hospitals, outpatient clinics, primary care clinics? Biomedical (vaccine) research agencies? Private corporations? Pharmaceutical industry? For example, it says industries should form an "alliance to support the local medical research facilities and medical supplies" (page 15). What could healthcare organizations or even policymakers do with this recommendation? The US healthcare system have private hospital set up at each community.

Response: The U.S. have a private set-up at each community, and for all the past years, the objective has been to earn profit. Approximately 80% of all the manufacturing supplies and products come from abroad (mostly countries having less manufacturing cost). When COVID-19 started back in February/March 2020 and all transportations were halted, hospitals all over the U.S. were short of supplies because most of the things were coming from abroad, and hospital followed a lean inventory concept.

In some areas of the U.S., breweries started converting their supply line and started making hand sanitizers, General Motors converted one of their assembly lines and started making respiratory equipment. The unforeseen scenario gave the U.S. manufacturing to develop a modular assembly line to support the need in the U.S. healthcare. Still all over the U.S., hospitals were waiting supplies from abroad which

no one could develop inside the U.S. (mainly because of the cost of manufacturing here is so high that hospitals can get the same product in bulk with much cheaper price from abroad).

Our keyframe recommendation was hospital managements need to create policies where they can partner alliances within their local community small businesses, private corporations, and research agencies (e.g., mechanical, electrical, garments manufacturing) where they can start consistent delivery of the basic local needs in a hospital, this will create the local inventory flow, and over the period of time, it can grow. And for any unforeseen scenario (like COVID-19), the U.S. hospitals can rely on their local transportation and manufacturing. Because the U.S. health system is mostly private, the hospital management was more focused in spending the cost on getting expensive workforce (e.g., Surgeons, MDs), marketing rather than balancing it over and pro-actively analyzing the risk assessments of unforeseen scenarios. Health facilities will have to broaden their inventory accruing and transportation need by partnering with the local industries to strengthen their need during unforeseen scenarios.

Comment: It is also not clear what type of paper this is. It says it is both a case study and conceptual paper (page 4). Under the section 'historical perspectives,' a lot of data is provided on patient flow, triage scenarios, length of stay and hospital operations. Where does this data come from?

Response: This paper carries both elements, i.e., case study and conceptual. The data is collected from a local community hospital (medium to large hospital serving a community population of over 150,000) in the U.S and reflect the percentage of different emergency severity level scenarios treated inside the hospital.

Comment: No citations are provided. Also, this section suggests that this paper is about balancing hospital operations, however, the paper digresses completely from a focus on hospitals to discussing a mishmash of challenges faced by the US healthcare system.

Response: To describe the challenges faced in the U.S. healthcare system, one has to look into the operational challenges inside the U.S. hospital and understand the flow from the start to finish (i.e., patient arriving to emergency, how its emergency severity determined, how it follows the inpatient procedures until the patient discharge). The root of the U.S. healthcare systems are the hospitals, the need here is that the hospital management starts proactive approach towards balancing their individual requirements.

Comment: The paper's title is misleading, because there is nothing in the paper's proposed framework (surveillance, workforce, modular facilities) about innovation or

technology.

Response: We respectfully disagree with the reviewer – our paper title is appropriate and in accordance with entire test of the manuscript and supporting illustrations, diagrams, etc. Please see pages 10 and page 11 onwards that starts explaining the proposed framework.

As one may appreciate that the first step proposed for the U.S. hospitals and healthcare facilities is to understand and develop a healthcare surveillance system locally and globally. Healthcare surveillance requires actual and factual studies. Local hospitals and healthcare sectors need to start hiring engineering discipline workforce. Healthcare historically has always neglected engineering data scientist and relayed more on medically research workforce, the future of hospitals and healthcare relay on many contributing engineering disciplines which can help the hospital management in making proactive decisions and creating policies that supports the community in unforeseen scenarios.

Furthermore, Figure 3 in this paper represents the healthcare surveillance model, where the center of triangle is management (it can be at any level government, local hospital, and/or community healthcare) which is linked with not only the medical researchers but requires engineer's contribution too. The U.S. hospitals are generally missing that engineering link, especially as noticed during the past year or so (COVID-19 era).

Comment: In fact, there is no mention of how the rapid acceleration of TELEHEALTH use during the pandemic served to change the dynamic of healthcare delivery with great benefits to public health during the pandemic.

Response: "Telehealth is effective to preventive care checkups, or routine checkup which mostly deals with outpatient's offices and clinics determined checkups". Telehealth did help during the pandemic but only with the preventive care and routine checkups. Telehealth success is linked with the technical engineering team that bridge the patient to doctor connection, this also involves the transportation cost. Indeed, the need for telehealth improved during pandemic because the outpatient medical doctors were losing revenue due to reduced/stopped medical visits, so the hospital managements were more supportive of and expanding the concept of telehealth to support the cost of medical offices. However, the human factor disadvantages of telehealth and patient satisfaction (largely unmet) remains a question, especially for the long-term treatment/management of patients at sub- or super-specialty clinics where multiple follow-ups are necessary in-person.

Indeed, our paper did not discuss the rapid acceleration of telehealth because it was

linked with only preventive care visits and involve more outpatient cost and profit. Telemedicine cannot support broader range of emergency severity risk patients and usage is limited for inpatients visits. The root cause analysis of the U.S. healthcare system is understanding the flow of inpatients in hospital and balancing the resources by making proactive planning.

Comment: Under the workforce solution, the paper says that the US should increase the number of medical schools and the production of physicians and other healthcare professionals. However, many HCOs were able to leverage existing TELEHEALTH infrastructure to effectively continue their operations with available workforce, because the technology (telehealth) infrastructure enabled them to deliver care more efficiently and safely.

Response: The second proposed framework after having the surveillance is building up workforce inside a hospital or healthcare facility. Figure 4 describes the need of workforce in hospitals. The tip of the pyramid is physicians. Page 7, reference 11 shows the U.S. physician to population ratio. Inside a hospital, the patient care is dependent on the doctor to patient ratio, and that's why one of the recommendations for local communities is to create graduate medical residency programs to support the doctor to patient ratio in a hospital or healthcare facility. Page 14, reference 17 explains the future supply and demand of physicians in the U.S.

Figure 4 (middle) explains how to better develop programs for nurses. The U.S. is facing a shortage of nurses in some hospitals of the U.S. and is rigorously hiring nurses from abroad to fulfill the patient to nurse demand too.

Figure 4 (base) explains the need of phlebotomists and diagnostic laboratory staff. Physicians define and analyze the problems, "but they rely on the laboratory test results to control and manage/cure the severity of the problems. There is a shortage of laboratory staff (for example; medical assistants, general laboratory technicians, microbiologists, and histologist technicians, etc.) who process and set the ground-limits so that physicians can read/interpret any new scenarios as recommended by the biomedical researchers and support staff". Creating a workforce who can support physicians in the reliability of laboratory processes is essential. Reference 19 and Reference 12 on page 15 can be seen about the Nurse and Phlebotomy requirements.

The HCOs started leveraging Telehealth because patient stooped visiting doctors' offices and the cost and profit ratio was disturbed to support the outpatient clinics.

Telehealth approached existed before the COVID-19 era, however, as noted above, Telehealth is effective to preventive care checkups, or routine checkup, which mostly deals with outpatient's offices and clinics determined checkups. Telehealth did help during the pandemic but only with the preventive care and routine checkups.

Comment: There is no alignment between the challenges identified in the earlier sections and the recommendations. For example, the entire write-up on surveillance, particularly on page 12, related to local and global health surveillance and the need for disease scientists, research scholars, vaccine scientists, engineering and pharmaceutical to be trained on stochastic modeling and surveillance does not tie back to the key problems presented on pages 3-4 related to hospital patient flow, triage, length of stay, and operations.

Response: Please note that first we described the background/history of the U.S. healthcare system using literature review, the next step was carrying out a root cause analysis by understanding the hospital flow and Emergency Severity Index, to describe the challenges faced in the U.S. healthcare system - one has to look into the operational challenges inside the U.S. hospital and understand the flow from the start to finish (i.e., patient arriving to emergency, how its emergency severity determined, how it follows the inpatient procedures until the patient discharge). The root of the U.S. healthcare systems are the hospitals, the need here is that the hospital/health facility management starts proactive approach towards balancing their individual requirements. This led to proposing three keyframe recommendations in our paper.

Figure 6 explains and linked the operational challenges identified in earlier sections, hospital patient flow, emergency severity level and the paper's proposed framework (surveillance, workforce, modular facilities). The flow diagram on the left side explains the operational and historical flow at any of the U.S. healthcare facility or hospital. The right side of the flow diagram explains how individual hospitals and healthcare facilities stakeholders need to analyze the bigger picture and start making policies which will improve and help them during the unforeseen scenarios.

Figure 6, left side link-up the five known healthcare scenarios to any new scenario to right side of flow diagram. Most of the time to explain the healthcare scenarios the medical researcher divides them into five categories and when a new scenario develops (say for example # 6), the researches/MDs' goal is to fix them in the known or existing five categories. The U.S. health system (hospitals & health facilities) are generally missing the right side of the process flow diagram. The management and stakeholder need to encounter this in their policy for better and long-lasting results.

Comment: Overall, the paper lacks a clear problem of interest, purpose, unit of analysis, and target audience. It also lacks a coherent flow and organization. The proposed framework does not address the problem of interest, because latter lacks clarity from the outset. These are fundamental flaws that would not be uncorrectable even with major revision. Correspondingly, I cannot recommend this paper for publication or

revision.

Response: We respect the personal opinion of the reviewer; however, we would like the re-emphasize that the healthcare is filled with highly educated people working in an often-emotional environment, and respect is essential when developing a new business performance system. The clear problem of interest in this paper is the U.S healthcare system, and the purpose of unit analysis is the U.S. hospitals and healthcare facilities has been laid out clearly. The proposed framework is linking the root cause analysis and risk analysis, and aiming to recommend a healthcare that's flexible, modular, adaptable, and operable at any unforeseen conditions. We strongly believe that our paper is logical and thoughtfully covers all the above noted points and deserves publication in the journal.

Reviewer B

Comment 1. There are some unofficial English and grammatical errors in the manuscript. Please review and revise them.

Response 1: We have carefully proof-read the manuscript and made appropriate corrections for English and grammar errors in the revised manuscript. The correction on each page is marked in red line on the left side of paper.

Comment 2. On page 3, please define the term "unforeseen scenarios" in the context of this paper.

Response 2. On page 3, the" unforeseen scenarios" applied in context to all the risk assessment analyzed and predicted by the healthcare management pre-COVID-19 era or during the ongoing COVID-19 period. For example, the demand of infectious disease MDs / intensivist MDs for the unforeseen scenarios, PPE supplies shortage, and the backlog in order status, etc.

One should recognize that the unforeseen scenarios always existed and will always keep their growing existence, however when the unforeseen happens it is the operational need that are thinned because no one have planned proactively to predict that stochastic approach. The stakeholders (mainly the healthcare facility management in USA) need to understand the growth and possibility of the unforeseen new medical risks, including how to challenge the dataset used for decision making, increasing the required acceptance level for the verification and validation of growing medical risk models, because healthcare is a stochastic system, forecasting always changes and so

does the final decision of investing the cost.

Comment 3. It is challenging to understand the ultimate goal of this study. The topic seems to be abstractive and broad. More specific aims of this study should be suggested at the end of the introduction part.

Response 3. In this paper, first, we described the background/history of the U.S. healthcare system using literature review, and the next step was carrying out a root cause analysis by understanding the hospital flow and Emergency Severity Index, which led to proposing three keyframe recommendations.

The U.S. health system is linked with private healthcare system, and every risk analysis is linked with cost. The U.S. health care system is unique and totally different from any other nation in this world. It is a very lean based system where every penny earned is billed for.

Figure 6 explains and linked the operational challenges identified in earlier sections, hospital patient flow, emergency severity level and our paper's proposed framework (surveillance, workforce, modular facilities).

The flow diagram (Figure 6) can be read as follows: on the left side, it explains the operational and historical flow at any of the U.S. healthcare facility or hospital. The right side of the flow diagram explains as to how individual hospitals' and healthcare facilities' stakeholders need to analyze the bigger picture - and start making policies which would improve and help them during the unforeseen scenarios.

Comment 4. On page 6, there are no references in the first paragraph. Please add the citations.

Response 4. The paragraph explains the emergency severity index in a hospital/health facility, reference [10] at the end of paragraph explain the five emergency severity levels. We added the citation in the revised manuscript.

Please note that Table 1 also explains the basic five different severity levels in the U.S. healthcare.

Comment 5. On page 9, most statements are opinion-oriented and need scientific evidence to support the author's assumption and prediction. Please add citations.

Response 5. The unforeseen scenario requires real time data, which most of the time is unavailable (or stochastic) and requires extensive industrial engineering methods to accept and/or reject the hypothesis. When COVID-19 pandemic happened, the hospitals and healthcare sectors were already missing this approach, which often led in poor

decision making. The American Hospital Association estimates a total four-month financial impact of $202.6 billion in losses for America's hospitals and healthcare systems, or an average of $50.7 billion per month. This included: i) the additional costs associated with the purchasing needed for personal protective equipment (PPE); and ii) the costs of the additional support some hospitals are providing to their workers.

We included the citation [12] in the revised manuscript.

Comment 6. On page 12, what does it mean "healthcare scenarios" in this paper? It's too broad, and needs the author's definition here.

Response 6. Yes, the" healthcare scenarios" are broad. Most of the time in order to explain the healthcare scenarios, the medical researchers divide them into five categories and when a new scenario develops (say for example # 6), the researches/MDs' goal is to fix them along with the known five categories. Figure 6 explains and linked the operational challenges identified in earlier sections, hospital patient flow, emergency severity level and our paper's proposed framework (surveillance, workforce, modular facilities).

The flow diagram on the left side explain the operational and historical flow at any of the U.S. healthcare facility or hospital. The right side of the flow diagram explains how individual hospitals and healthcare facilities' stakeholders need to analyze the bigger picture and start making policies which would improve and help them during the unforeseen scenarios.

Figure 6, left side link up the five known healthcare scenarios to any new scenario to the right side of flow diagram. As noted above, most of the time to explain the healthcare scenarios, the medical researcher divides them into five categories and when a new scenario develops (say for example # 6), the researches/MDs' goal is to fix them with the known five categories. The U.S. health system (hospitals & health facilities) are missing the right side of the process flow diagram. The management and stakeholder to encounter this in their policy for better and long-lasting results.

Comment 7. On page 12, Do disease scientists include healthcare providers? Needs clarification here.

Response 7. The disease scientists comprise of infectious disease medical doctors and pharmaceutical doctors.