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ORIGINAL RESEARCH

# Empowering Healthcare Agility: A Strategic Framework for Pandemic-Responsive Operational Planning

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**Introduction:** The COVID-19 pandemic has challenged healthcare systems globally, testing their resilience due to sudden fluctuations in confirmed cases, intensive care unit utilization, and medical team availability. These dynamics forced healthcare facilities to continuously adapt their operational plans.

**Methods:** This research conducts a comprehensive review of published changes implemented by various healthcare facilities in response to the pandemic.

**Results:** The study provides new insights into enabling healthcare agility during pandemics such as COVID-19. A decision-making framework is proposed to assist hospital management in exploring and selecting appropriate alternatives, allowing faster adaptation in dynamic environments.

**Discussion:** The framework can be tailored to each hospital's unique characteristics and the prevailing epidemiological situation. Future research could explore the use of simulation to automate the development of dynamic operational plans based on pre-selected criteria, further enhancing healthcare responsiveness.

**Keywords:** healthcare, dynamic, planning, COVID-19, pandemic

## Introduction

The COVID-19 pandemic has challenged healthcare systems globally. It had a long-lasting impact on the stability of some healthcare systems while driving others to their breaking point. The delivery of healthcare services for millions of people was disrupted while the demand for treating COVID-19 patients surged. Some of the effects included a significant decrease in surgeries, longer surgical wait times, and a negative influence on medical training for case involvement.[1] When healthcare systems are overloaded, direct and indirect mortality from preventable and treatable illnesses rise.

Surprisingly, the consequences of frequently issuing multiple guidelines in a short period were highly conflicting, resulting in a poor understanding and lack of applicability.[1–4] As new information about the virus's nature and its spreading patterns were emerging, hospitals had to respond swiftly to achieve the right balance between safety and efficiency.

Another challenge was manifested by sudden changes in the availability of medical professionals.[5–10] Some were in close contact with COVID-19 patients, which meant they had to quarantine. Others were infected or lost their lives in the pandemic. Requiring health workers to be vaccinated before reporting to their jobs meant some were prevented from assuming their responsibilities. Agile scheduling and rotation of workforce is essential to ensure care is delivered to those who need it most.[11]

The epidemiological situation seems to be constantly changing. Globally, the virus evolved through multiple mutations and variants since the beginning of the pandemic. In addition, uncertainty surrounding the availability and efficacy of vaccines overshadowed the forecasting and planning efforts. Locally, cases, hospitalization rates and intensive

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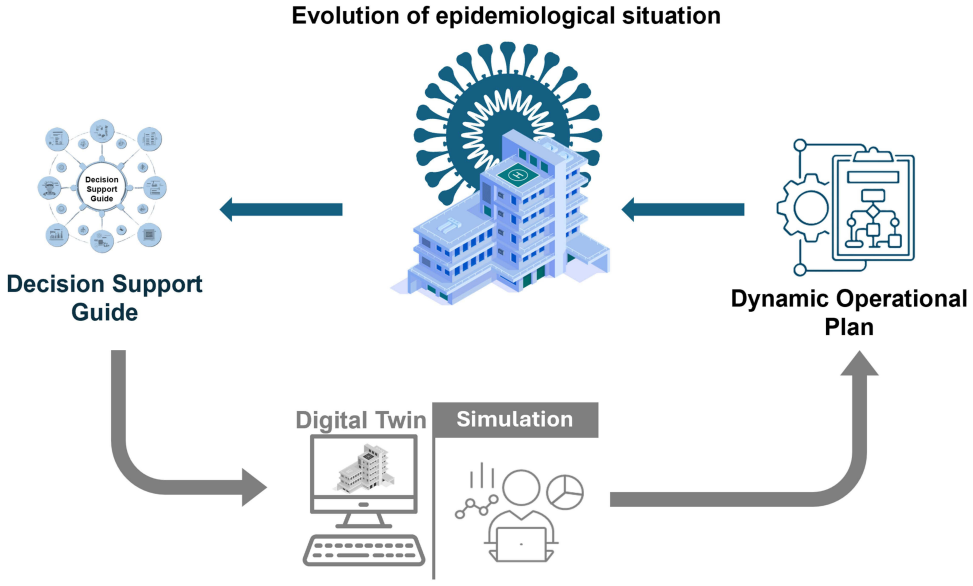
**Graphical Abstract**




care unit utilization were fluctuating. As a result, the assessment of these variables and their implications on operational planning is a continuous endeavor.

Evidence suggests that healthcare systems can only defeat pandemics if they are prepared and responsive on a sustainable scale.[12–16] The fast-paced changes in the COVID-19 pandemic necessitate agile and dynamic operational planning to ensure the healthcare system is optimized. This study therefore set out to propose a framework that supports healthcare facilities in developing dynamic operational plans during the COVID-19 pandemic.

## Related Work

More recent attention has focused on the capability of healthcare facilities to respond effectively during pandemics. This includes examining adaptations and changes made by hospitals and clinics in the wake of COVID-19, In addition to investigating factors that affect readiness both internally and externally. Lessons learned from previous epidemics such as SARS and MERS indicate that it is inevitable to ensure that national policies can be cascaded and implemented locally. Challenges that impair preparedness include identifying best practices and translating them into actionable plans and protocols.[9,10,12,17]

Harris et al[18] documented the modifications made by addiction consult services across four hospitals in North America. It is evident that access to healthcare for patients with substance use disorders was adversely affected by COVID-19. The hospitals reacted by implementing adaptations in four main areas: System, treatment, harm reduction, and discharge planning.

The adaptation impacted patients positively. For example, shifting regular appointments to telephone-based consultations allowed physicians to provide a level of care while adhering to COVID-19 protocols and preserving Personal Protective Equipment (PPE). Additionally, regulatory changes such as longer prescriptions and safe supply programs enhanced the engagement and access for patients. While some recommendations are specific to addiction consult services, other clinical areas can benefit by tailoring the lessons learned to their requirements.

O'Rielly et al[1] identified the strategies implemented by surgical services in response to COVID-19. A rapid scoping review of 132 articles was conducted. As illustrated in Figure 1, reorganizations of surgical services were categorized into six domains. One of the most common changes was canceling or postponing non-urgent operations which had a significant impact on patients worldwide. It is worth mentioning that prioritization of patients varied significantly and is

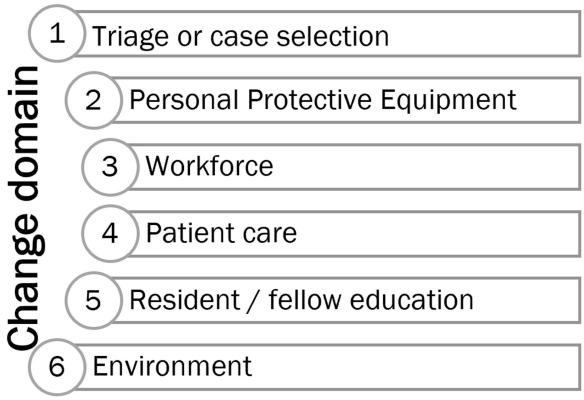



**Figure 1** Domains of changes to surgical services.
**Notes:** Adapted from O'Rielly C, Ng-Kamstra J, Kania-Richmond A, et al. Surgery and COVID-19: a rapid scoping review of the impact of the first wave of COVID-19 on surgical services. *BMJ Open*. 2021;11(6). Creative Commons.[1]

susceptible to change periodically. The authors highlighted that reorganization of surgical services varies widely and depends on the local characteristics.

Meyer et al[19] developed a checklist to assess the resilience of health systems to pandemics and natural hazards. A scoping review of scholarly databases coupled with interviews and a pilot workshop for validation were conducted. Ten themes for the checklist were identified as shown in Figure 2. Each theme includes a number of specific items that are assigned to an actor either on the facility-level or the health official-level.


**Figure 2** Health system resilience improvement checklist. Data from Meyer et al.[19]

The checklist can be used to assess the resilience of national health systems to respond to infectious diseases. Although in need of refinement and piloting, it can assist by identifying strategic factors while developing operational plans for healthcare facilities.

Mohammadpour et al[20] conducted a thorough scoping review to identify the main factors that affected the readiness and responsiveness of countries during pandemics. As shown in Figure 3, five main themes emerged. Readiness of hospitals and health centers and managerial interventions are internal factors that can be managed by health centers. On the other hand, socioeconomic and environmental factors are external and needs to be managed nationally/ internationally. Community-related interventions has both internal and external dimensions which requires a strong partnership between the healthcare sector and other players in the ecosystem. These themes are associated with 38 generic sub-factors that clarify the interaction between the themes and the preparedness of healthcare systems.

On the other hand, few researchers proposed a tool to support operational planning for healthcare facilities during pandemics. Güler and Geçici[21] developed a model to prepare the workforce shift schedule of a hospital in Turkey during COVID-19. Three new departments were established in the hospital to ensure a better response to the pandemic. A mixed-integer programming model is developed with the aim of minimizing the staff exposure to COVID while balancing the workload. Ordu et al[22] developed a more comprehensive simulation model incorporating all services provided by the hospital. A linear optimization model was then utilized to investigate the required be capacity and workforce requirements. However, both publications are narrow in the optimized parameters (bed capacity and shift schedules). In addition, they do not cover the alternative actions that can be taken by the healthcare facility.

While there are sufficient COIVD-19 guidelines issued by relevant ministries and bodies, it lacks specific instructions that enable health facilities to translate them into robust plans.[1,16,23–25] This could be one of the reasons that guidelines are not widely adopted in practice.[26] In addition, these guidelines are frequently updated to reflect new knowledge about the virus or the epidemiological situation locally and nationally.[2,27] This emphasizes the need for a flexible plan that can be updated regularly to respond to new changes. Although not widely implemented in the healthcare industry, process simulation seems to have the potential to facilitate dynamic operational planning.[28–31]


**Figure 3** Level of factors that affect the readiness of healthcare systems during pandemics.
**Notes:** Adapted from Mohammadpour M, Zarifinezhad E, Ghanbarzadegan A, Naderimanesh K, Shaarbafchizadeh N, Bastani P. Main factors affecting the readiness and responsiveness of healthcare systems during epidemic crises: a scoping review on cases of sars, mers, and covid-19. *Iran J Med Sci*. 2021;46(2):81–92. Creative Commons.[20]

The studies presented thus far provide useful insights on the changes made by hospitals in response to COVID-19 in addition to generic frameworks that encompass both internal and external factors that affect preparedness to pandemics. It seems there is a need for a tool to support planning and decision-making on the facility level. The tool needs to support flexible planning to account for the rapid changes as well as the ability to be tailored to local characteristics.

## Methodology

As shown in Figure 4, the research methodology consisted of four main steps. To begin this process, the research question and scope were identified. The main research question was "How to enable healthcare systems to develop and implement dynamic operational plans during the COVID-19 pandemic?". COVID-19 is a worldwide pandemic that affects all countries, so there are no geographical restrictions. The content is designed to include all the approaches, factors, and issues that influence healthcare systems' readiness and responsiveness during a pandemic.

The authors aimed to establish an evidence base of relevant research to enhance information retrieval approaches. The authors found studies initially using their expertise of the topic area and then by regular tracking of citations in key papers. The search approach entails a topic title, abstract, and keywords identifying healthcare readiness and the changes made in healthcare facilities as a result of the pandemic. The papers were selected to ensure that they included both observations and frameworks that handle healthcare readiness issues during the pandemic.

The authors obtained qualitative data from studies on modifications in healthcare facilities in response to the pandemic. Data synthesis and analysis covered a wide range of factors influencing the readiness of the healthcare system. The focus was mainly on changes that had implications for operational planning. The factors were grouped into five categories: screening procedures, workforce management, treatment prioritization, patient care, and facility planning.

Finally, a framework for dynamic operational planning is proposed by outlining all possible actions and alternatives that can be made by decision-makers in healthcare facilities during the pandemic.

## Results and Discussion

The modifications and changes affecting the planning of healthcare facilities during COVID-19 were analyzed and classified into five main categories as shown in Figure 5. In addition, several examples of documented changes are provided. Each change affects operational planning by introducing new tasks or procedures that require re-assigning current resources or schedules. In some cases, shortage of resources could occur which may necessitate recruiting new teams, securing larger budgets or obtaining specific equipment.

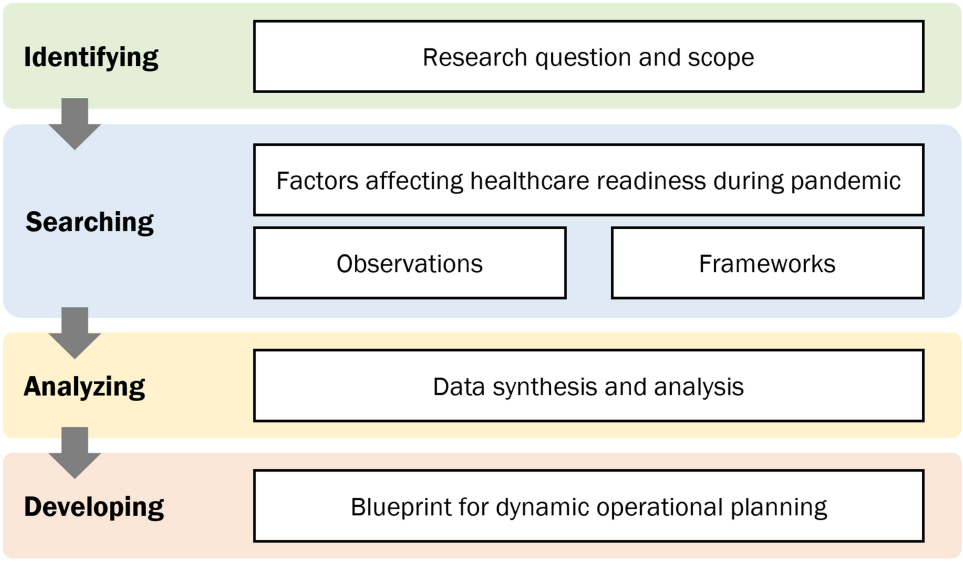



**Figure 4** Research methodology.

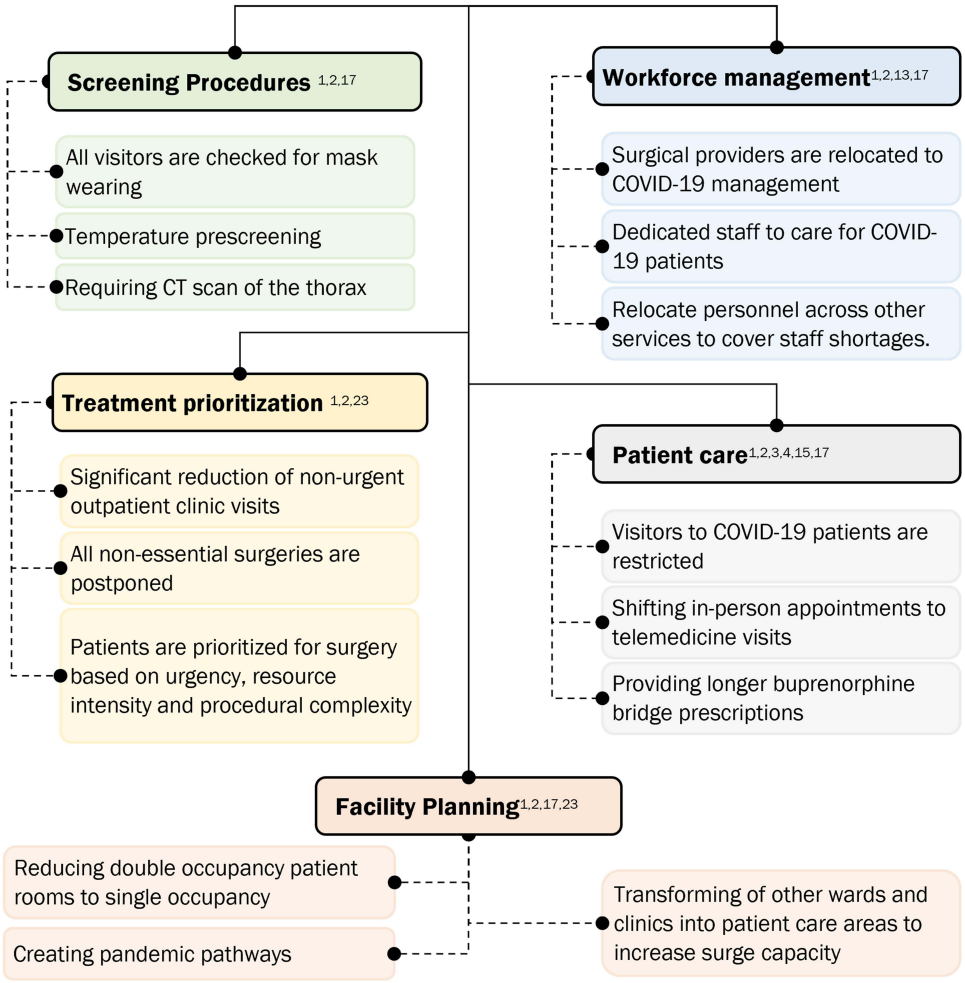



**Figure 5** Categories changes affecting the planning of healthcare facilities during COVID-19.

Screening procedures are introduced to filter patients/employees/visitors who have a high risk of infection in addition to ensuring that everybody entering the facility is adhering to the current protocols. It can include installing non-contact thermometers and enforcing the use of masks.

Workforce management aims to optimize the availability and efficiency of human resources. Staff schedules and assignments might need regular updates as a result of relocation to cover shortages during peaks. Several workgroups can be established to enable contact tracing and minimize exposure to infection.

Treatment prioritization outlines the criteria for treating patients during different stages of the pandemic. In some instances, a large number of operations and visits might be canceled considering as little effect as possible to patients. Depending on the available capacity and related COVID-19 forecasts, resuming visits and operations gradually requires criteria that will prioritize orders in the backlog based on factors such as urgency, resource intensity and procedural complexity.

Patient care defines how healthcare services are delivered to the patient. Changing in-person appointments to telemedicine visits will reduce the influx of patients coming to the hospital, preserve PPE and it might require specific devices or technology. Likewise, providing patients with longer prescription affects the number of hospital visits in the medium term.

Facility planning involves changes to the use of spaces and assets to respond better to the pandemic. For instance, the occupancy of double rooms may be reduced to single occupancy to minimize the risk of virus transmission and maintain the required social distance. That in turn, will have a significant impact on the number of in-patients a healthcare facility can treat. This system of classification provides the basis for a framework to enable dynamic operational planning during the COVID-19 pandemic. As illustrated in Figure 6, each stage of the proposed includes specific procedures that can be implemented by the decision-maker to respond to the epidemiological crises' situation.

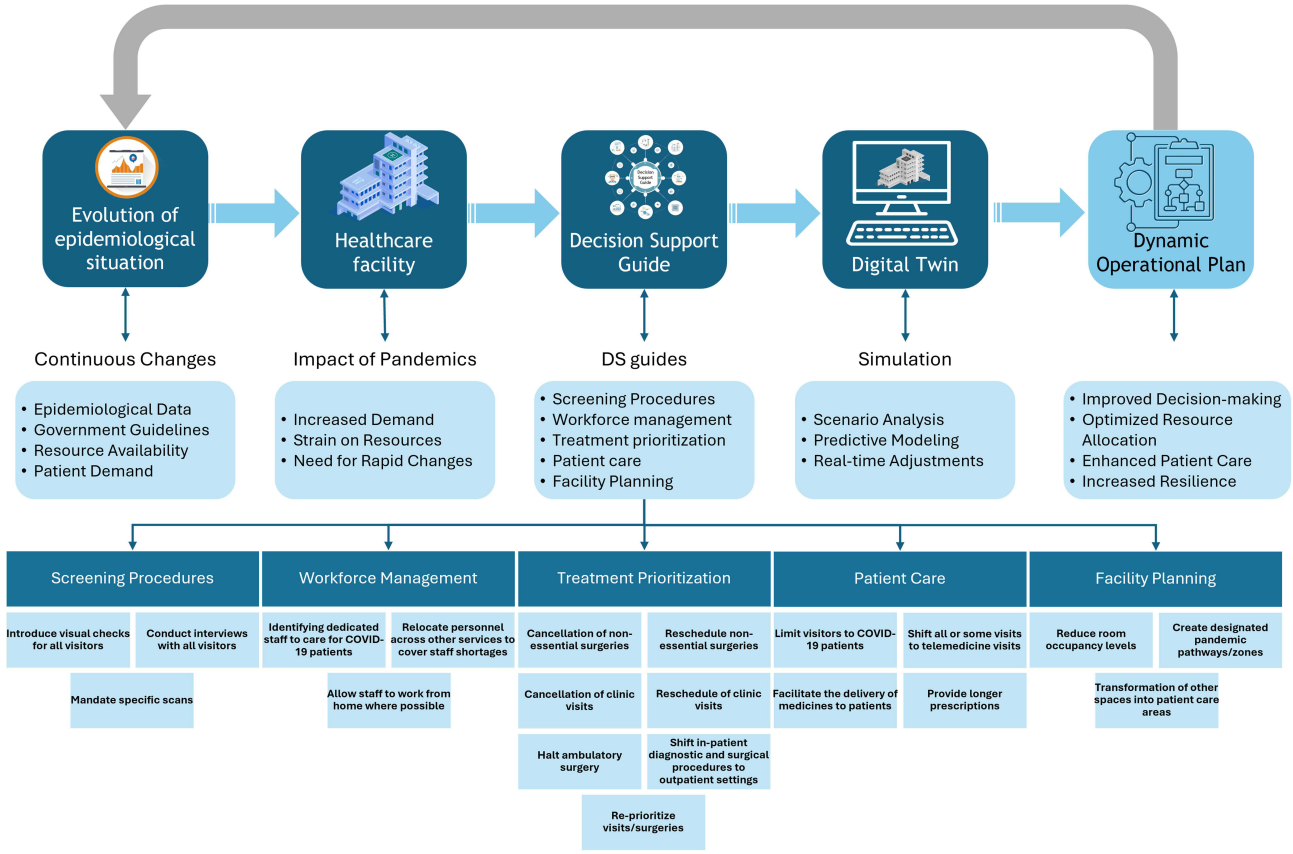



**Figure 6** A Strategic Framework for Pandemic-Responsive Operational Planning.

The proposed framework provides a comprehensive approach to enable dynamic operational planning for healthcare facility in response to evolving epidemiological crises, such as COVID-19 pandemic. The first stage is the evolution of the epidemiological situation, which encompasses critical inputs such as epidemiological data, government guidelines, resource availability, and patient demand. These inputs reflect the continuous changes that affect the epidemiological situation in the healthcare facility. The healthcare facility is impacted by pandemics, so it is faced with increased demand, resource shortages, and the need for rapid changes to reach a decision support guide.

The decision support guide emphasizes the importance of screening procedure, workforce management, treatment prioritization, patient care, and facility planning to face these challenges effectively. It facilitates the rapid development of dynamic strategies that prioritize critical treatments and enables the efficient allocation of space and personnel within healthcare settings. To enhance the agility of these decisions, the framework incorporates the concept of a digital twin which is a virtual model of the healthcare system that enables real-time simulation and scenario analysis. By employing predictive modeling, healthcare leaders can anticipate various future scenarios and adjust operations dynamically to mitigate risks and optimize resource utilization. This technological innovation supports continuous improvements in decision-making and allows for timely interventions as new epidemiological data becomes available.

The benefit of this framework is the development of a dynamic operational plan that improves decision-making, optimizes resource allocation, enhances patient care, and increases resilience. By integrating digital tools and data-driven insights, this framework provides a powerful methodology for strengthening healthcare systems, ensuring they can respond effectively to public health crises, and safeguarding the well-being of patients through informed, timely, and adaptive decision-making.

As a result, the facility's operational plan will be updated accordingly. The framework can be consulted regularly as the local and global epidemiological situation evolves. The key actions under each category are explained below.

## Screening Procedures

- Introduce visual checks for all visitors such as measuring body temperature and confirming patient health status in mobile health applications
- Conduct interviews with all visitors to find out the infection risk level. For example, asking about their traveling history, symptoms, and signs
- Mandate specific scans. In some cases, specific scans can help in identifying patients' status before surgery such as tomography scans

## Workforce Management

- Identifying dedicated staff to care for COVID-19 patients by creating separate teams and schedules for the medical staff
- Relocate personnel across other services to cover staff shortages. This might require induction and specialized training to allow the team to hold the new responsibilities
- Allow staff to work from home where possible. Communication can be established through information technology applications and devices

## Treatment Prioritization

- Cancellation of non-essential surgeries/ clinic visits. It is necessary to define "non-essential" surgeries and decide the extent to which volume surgeries and visits are to be canceled.
- Reschedule non-essential surgeries/ clinic visits. In this option, certain surgeries/ visits are not canceled but postponed to future dates
- Halt ambulatory surgery and redirect resources to focus on COVID-19 patients
- Shift in-patient diagnostic and surgical procedures to outpatient settings in order to free more resources for COVID-19 patients
- Re-prioritize visits/surgeries. Apply different prioritization rules to either new requests or the current orders in the schedule and the backlog

## Patient Care

- Limit visitors to COVID-19 patients to reduce the incoming flow into the facility and reduce the chance of infections
- Shift all or some visits to telemedicine visits. This will reduce the direct contacts in the hospital while preserving much needed PPE
- Facilitate the delivery of medicines to patients. This could include using distribution points outside the healthcare facility or the delivery of medication to patients homes
- Provide longer prescriptions to reduce the volume of patients coming to the facility in the foreseeable future
- Prioritize noninvasive diagnostic procedures (eg, lung ultrasound, remote monitoring) to reduce aerosol-generating interventions and viral exposure

## Facility Planning

- Reduce room occupancy levels to maintain the required social distancing protocols
- Create designated pandemic pathways/zones to control infection exposure between divisions and to ensure that if an outbreak occurs, it would not affect the whole hospital
- Transformation of other spaces into patient care areas to increase surge capacity

This framework will prove useful in enabling dynamic operational planning during the COVID-19 pandemic. It provides a comprehensive summary of published changes made by various healthcare facilities in response to the pandemic. It can assist management in exploring and selecting the appropriate alternatives, allowing them to make decisions faster in

a dynamic environment. Moreover, it can be tailored to each hospital based on its unique characteristics and the current epidemiological situation. Also, it lays the foundation for the development of a tool that automatically generates operational plans based on pre-selected criteria.

While the proposed framework offers a structured approach to dynamic operational planning, its implementation poses several challenges. The framework assumes the availability of accurate and timely epidemiological data, which may be compromised due to reporting delays, inconsistencies in healthcare information systems, or limited access to real-time patient flow data. Additionally, organizational resistance to change can impede the adoption of dynamic planning strategies, particularly in healthcare institutions with rigid administrative structures and established protocols. The framework may also require contextual adaptation, as its direct applicability could vary across different healthcare systems with diverse infrastructures and resource capacities. Furthermore, although the framework enhances decision-making, it does not eliminate the inherent uncertainty of pandemics, where unexpected surges in patient volume or evolving disease characteristics necessitate continuous adjustments. Overcoming these challenges requires a multidisciplinary approach, fostering collaboration among healthcare administrators, policymakers, and technology experts to ensure the framework's seamless integration and long-term effectiveness.

## Conclusions

The COVID-19 pandemic stressed healthcare systems globally. The rapid changes required healthcare facilities to be agile in order to optimize their operations and achieve the right balance between productivity and safety. The purpose of the current study was to develop a framework to aid healthcare facilities in developing dynamic operational plans during the COVID-19 pandemic.

The published modifications in healthcare facilities in response to COVID-19 were analyzed and grouped into five main categories. In addition, we propose a framework to enable dynamic operational planning during the COVID-19 pandemic. It includes specific actions and alternatives that can be selected by the decision-maker while developing the plan. In practice, the implementation of these alternatives and modifications will vary depending on the unique characteristics of the facilities and the surrounding epidemiological situation.

Further research could be conducted to develop a framework that supports decision-making not only in COVID-19 and similar pandemics induced by respiratory infections but in all types of pandemics in general. In addition, a future study could evaluate the use of simulation in automating the process of developing dynamic operational plans.

## Acknowledgment

This paper has been uploaded to ResearchSquare as a preprint: https://www.researchsquare.com/article/rs-2317940/v1

## Disclosure

The authors declare no conflicts of interest in this work.

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