Centre universitaire de santé McGill

McGill University Health Centre

Technology Assessment Unit of the McGill University Health Centre (MUHC)

The Feasibility and Clinical Value of Establishing Hospital Capacity Command Centres

La faisabilité et la valeur clinique d'un centre de commandement pour la gestion de la capacité de l'hôpital

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Report prepared for the Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC)

by

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Approved by the Policy Committee of the TAU

Mission Statement

The MUHC Health Technology Assessment Unit (TAU) advises hospital administrators and clinical teams in difficult resource allocation decisions. Using an approach based on independent, critical evaluations of the available scientific evidence and a transparent, fair decision-making process, novel and existing medical equipment, drugs and procedures used by healthcare professionals are prioritized on a continuous basis ensuring the best care for life with the best use of resources.

TAU Policy Committee

Declaration of Conflicts of Interest

Members of TAU's research staff and policy committee declare no conflicts of interest.

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- John Fletcher, Executive Advisor, Data Analysis and Valorization, DQEPE, MUHC
- Jim Scheulen, Chief Administrative Officer of the Judy Reitz Command Center of the Johns Hopkins Hospital, Baltimore, Maryland;
- Monica Stone, Senior Project Administrator of the Johns Hopkins Hospital
- Carolyne Crowley, Director of the Carrefour Santé Aline-Chrétien Health Hub (CSAC)
- Lise Vaillancourt, former director of hospital performance at the Montfort Hospital, Ottawa, Ontario
- Joanne Coté, director of quality, innovation, and performance at the West-Central Montreal’s Centre Integré Universitaire de santé et de service sociaux (CIUSSS) about the Jewish General Hospital’s command centre
- Zahava Uddin, the Managing Director of GE Healthcare Command Center
- Gordon Peckham, Senior Director for Care Coordination Centre Operations at Nova Scotia Health; Doris Grant, Senior Director for Innovation at Nova Scotia Health; and Jonathan Veale, Chief Design Officer at the Nova Scotia Department of Health and Wellness

REPORT REQUESTOR

This report was requested by Marie-Ève Lefebvre of the Transformation Department of the Direction des projets majeurs d'infrastructures (DPMI) of the CISSS de la Montérégie-Ouest (CISSS-MO) on September 16, 2021.

TYPES OF RECOMMENDATIONS ISSUED BY THE TAU COMMITTEE

Type of recommendation	Explanation
Approved	• Evidence for relevant decision criteria, including efficacy, safety, and cost, as well as context-specific factors such as feasibility, is sufficiently strong to justify a recommendation that the technology be accepted, used and funded through the institutional operating budget
Approved for evaluation	• There is a reasonable *probability* that relevant decision criteria, including efficacy, safety, and cost, as well as context-specific factors such as feasibility, are favorable but the evidence is not yet sufficiently strong to support a recommendation for permanent and routine approval. • The evidence is sufficiently strong to recommend a *temporary* approval in a restricted population for the purposes of evaluation, funded through the institutional operating budget.
Not approved	• There is insufficient evidence for the relevant decision criteria, including efficacy, safety, and cost; • The costs of any use of the technology (e.g. for research purposes) should not normally be covered by the institutional budget.

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ABSTRACT

- While there is no consensus definition, hospital capacity command centre (CCCs) can be defined as "physical and cross-functional units involving (i) co-location of interdisciplinary workgroups exerting significant influence over patient flow (ii) use of real-time data integrated from sources including electronic health records, and (iii) management of two or more processes related to patient flow (e.g., admission services, bed management, interhospital transfer management, patient transport, environmental services, etc.). Another essential characteristic of CCC is using artificial intelligence and machine learning for predictive analytics and scoring systems. Hospital capacity command centres are expected to have an impact on hospital overcrowding through more efficient patient flow, bed management and data access.
- The objective of this report was to review the available scientific and experiential evidence for the feasibility and clinical value of establishing a hospital capacity command centre to manage patient flow and bed capacity.
- We conducted a scoping review and identified 14 hospital capacity command centres in the United States and 2 in Canada from 12 studies (11 observational, one review), and nine report, press release, magazine, or trade journal articles. Bed management is the key element in all centres. Transfer management was covered in 10 (62.5%) while patient transport and environmental system (EVS) in 9 (56.3%) CCCs.
- There are no randomized controlled trials (RCTs) to date evaluating the efficacy of CCCs. There is no comparative study: all studies used a pre-post design (i.e., before and after CCC establishment without control). Hence, we were unable to simultaneously compare CCC with other strategies. Moreover, there is a lack of standardized performance indicators of CCC. Nonetheless, these studies demonstrated improvement in various indicators such as the emergency department (ED) boarding, length of stay, transfer time, ambulance and ED diversion, and patient satisfaction. Improvement in organizational performance was also observed.
- Experiential data from several established hospital capacity command centres in the US and Canada indicated that the integration of such systems has had an impact on better patient experience and hospital efficiency.
- The cost of establishing CCCs varies based on the need for physical space, number and type of prediction software, the number of electronic medical records (EMR) instances, the size of the organization, and the level of activation support from the software provider.
- Other important factors that should be considered in establishing a CCC include setting the targets and indicators, data infrastructure, interface ability of different software, and disruptiveness.

- Finally, all studies and correspondents highlighted that acceptance of cultural change and strong commitment from hospital staff and management are important for the success of their command centres. Furthermore, a solid governance structure is necessary to establish policies for tracking and sustainability.

RÉSUMÉ

- Bien qu'il n'existe pas de définition consensuelle, les centres de commandement pour la gestion de la capacité (« centres de commandement ») des hôpitaux désignent des unités physiques et interfonctionnelles qui impliquent i) la colocalisation de groupes de travail interdisciplinaires qui exercent une influence importante sur le cheminement des patients; ii) l'utilisation de données en temps réel intégrées à partir de sources, dont les dossiers cliniques informatisés; et iii) la gestion d'au moins deux processus liés au cheminement des patients (par exemple, les services d'admission, la gestion des lits, la gestion des transferts interhôpitaux, le transport des patients et les services environnementaux). Un autre aspect essentiel des centres de commandement est l'utilisation de l'intelligence artificielle et de l'apprentissage automatique pour les analyses prédictives et les systèmes de notation. Ces centres devraient avoir une incidence sur l'engorgement des hôpitaux grâce à leur efficacité accrue du cheminement des patients, de la gestion des lits et de l'accès aux données.
- Le présent rapport a pour objectif d'examiner les preuves scientifiques et expérientielles dont on dispose sur la faisabilité et la valeur clinique d'un centre de commandement pour un hôpital en ce qui a trait au cheminement des patients et à la capacité en lits.
- Nous avons effectué une revue exploratoire de 12 études (11 études observationnelles et 1 revue d'étude) ainsi que de 9 rapports, communiqués de presse, magazines et articles de revues professionnelles, et avons ciblé 14 centres de commandement aux États-Unis et 2 au Canada. Tous ces centres ont la gestion des lits comme élément principal. Dix impliquent la gestion des transferts (62,5 %), et neuf le transport des patients et le système de services environnementaux (56,3 %).
- À ce jour, il n'existe pas d'essai clinique randomisé sur l'efficacité des centres de commandement ni d'étude comparative (toutes les études disposent d'un plan expérimental pré et post-test, c'est-à-dire avant et après la mise en place d'un centre de commandement, sans groupe de contrôle). Par conséquent, nous n'avons pas été en mesure de comparer simultanément les centres de commandement avec d'autres stratégies. De plus, il n'existe aucun indicateur normalisé de performance pour ces centres. Néanmoins, ces études démontrent une amélioration de divers indicateurs tels que l'accueil à l'urgence, la durée du séjour, le temps de transfert, le détournement des ambulances et des urgences, et la satisfaction des usagers. On a également observé une performance accrue des organisations.
- Les données expérientielles de plusieurs centres de commandement aux États-Unis et au Canada indiquent que l'intégration de ces systèmes a eu une incidence sur l'amélioration de l'expérience des usagers et de l'efficacité des hôpitaux.

- Le coût pour la mise en place de ces centres varie selon le besoin d’espace physique, le nombre et le type de logiciels de prédiction, le nombre d’instances d’archives médicales informatisées, la taille de l’organisation, et le degré de soutien de la part du fournisseur lors de l’activation des logiciels.
- L’établissement des objectifs et des indicateurs, l’infrastructure de données, la capacité d’interface des différents logiciels et le caractère perturbateur figurent parmi les autres facteurs importants à prendre en compte pour la mise en place d’un centre de commandement.
- Toutes les études et tous les correspondants soulignent que l’acceptation du changement culturel et la forte participation du personnel hospitalier et de la direction ont une incidence sur l’efficacité des centres de commandement. Aussi, une structure solide de gouvernance est nécessaire pour la mise en œuvre de politiques de suivi et de viabilité.

EXECUTIVE SUMMARY

BACKGROUND

While there is no consensus definition, hospital capacity command centre (CCCs) can be defined as "physical and cross-functional units involving (i) co-location of interdisciplinary workgroups exerting significant influence over patient flow (e.g., admissions, bed management, environmental services, transfer management, etc.), (ii) use of real-time data integrated from sources including electronic health records, and (iii) management of two or more processes related to patient flow (e.g., admission services, bed management, interhospital transfer management, patient transport, environmental services, etc." Another essential characteristic of CCC is using artificial intelligence and machine learning for predictive analytics and scoring systems.

Hospital capacity command centres are expected to help with hospital overcrowding through more efficient patient flow, bed management and data access. One of the biggest factors affecting patient flow is patients in alternate levels of care (ALC) or "users waiting for ALC", a term used for a patient who "is occupying a bed in a facility and does not require the intensity of resources/services provided in that care setting". In turn, ALCs can cause overflowing emergency rooms and higher costs (i.e., the effects of ALCs). Flow management by integrating various documented health care systems and projecting them into dashboards that present real-time data and mathematical models to understand and predict patient flow (i.e., command centre) is seen as a solution to reduce the number of users waiting for ALC.

In September 2021, the Health Technology Assessment Unit (TAU) received a request from the Transformation Department of the direction des projets majeurs d'infrastructures (DPMI) of the CISSS de la Montérégie-Ouest (CISSS-MO), who wanted to evaluate the feasibility of establishing a command centre for patient flow at their new hospital. The hospital, planned for completion in 2026 in Vaudreuil-Soulanges, Quebec, will have a capacity of 404 beds and more than 3,200 new employees. The new hospital is expected to be a 'smart' hospital, i.e. fully digital, to provide the best and safest care.

OBJECTIVES

The objectives of this report are to evaluate

- the feasibility and clinical value of establishing a hospital capacity command centre to manage hospital patient flow and bed capacity
- the cost of establishing and operating a hospital capacity command centre

METHODS

Literature review

We conducted a scoping review on hospital capacity command centres by searching PubMed and the health technology assessment (HTA) database of the Centre for Reviews and Dissemination.

Costs

We obtained cost estimates of establishing a Capacity Command Centre through interviews with Ms. Zahava Uddin, the Managing Director of GE Healthcare Command Centre.

Experience at the MUHC and Elsewhere

Experience at the MUHC and hospitals with established command centres was obtained through correspondents, interviews, or information sessions with the following people:

- Dr. Frederic Dankoff, MUHC Medical Coordinator for Bed Management and Patient Flow, to describe current practice at the MUHC;
- Dr. Marc Beique, Emergency Medicine Physician and Emergency Department IT Director, MUHC;
- Mona Maalouf, Infocentre-Performance Manager, Direction of Quality, Evaluation, Performance and Ethics (DQEPE), MUHC;
- John Fletcher, Executive Advisor, Data Analysis and Valorization, DQEPE, MUHC;
- Jim Scheulen, Chief Administrative Officer of the Judy Reitz Command Centre of the Johns Hopkins Hospital, Baltimore, Maryland;
- Monica Stone, Senior Project Administrator of the Johns Hopkins Hospital;
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- Joanne Coté, director of quality, innovation, and performance at the West-Central Montreal’s Centre Integré Universitaire de santé et de service sociaux (CIUSSS) about the Jewish General Hospital’s command centre;
- Gordon Peckham, Senior Director for Care Coordination Centre Operations at Nova Scotia Health, Doris Grant, Senior Director for Innovation at Nova Scotia Health and Jonathan Veale, Chief Design Officer at the Nova Scotia Department of Health and Wellness.

RESULTS

Literature review

- We identified 14 hospital capacity command centres in the US and 2 in Canada from 12 studies (11 observational, one review), and nine report, press release, magazine, or trade journal articles (Figure 1). Bed management is the key element in all centres. Transfer management was covered in 10 (62.5%), patient transport and environmental service system in 9 (56.3%), admission in 7 (43.8%), and case management in 5 (31.3%) CCCs.
- Indicators of emergency department (ED) boarding were used in 8 (50%) CCCs. Over a time period ranging from 1 to 5 years after CCC operation, all showed a decline in ED boarding time. Others reported improvement in various indicators such as length of stay, transfer volume and time, ambulance and ED diversion, and patient satisfaction. Improvement in organizational performance (e.g., decreased number of phone calls per bed assignment/patient placement, paper forms used, length of the end-of-shift admission coordinator reports, and increased throughput by alerting bed managers to discharges sooner) was also observed.
- There are no RCTs to date evaluating the efficacy of CCCs. There is no comparative study: all available studies are limited by their pre-post design (i.e., before and after CCC establishment without control), leaving us unable to simultaneously compare CCC with other strategies. Moreover, there is a lack of standardized indicators to evaluate the performance of CCC. Some centres reported median ambulance pick up time, while others reported transfer time from dispatch to pick up or time to complete a transfer from another facility as a performance indicator related to transfer management. This heterogeneity restricts the generalizability of findings.

Experiential Data

A number of hospitals in Canada and the US have established command centres to facilitate patient flow. In general, they have found that command centres have an impact on the following:

- Patients: command centres improve patient experience by accelerating the process of care delivery, which in return results in better, faster, and safer patient care;
- Healthcare professionals: command centres enhance communication and improve workflows efficiency;
- Hospital administrators: command centres enhance hospital efficiency, accountability, and continuous improvement

- Health care system: command centres provide a more efficient system by enhancing transfer management using real-time data between healthcare facilities within the network.

Costs

- Ms. Zahava Uddin, the Managing Director of GE Healthcare Command Centre explained the components and costs of implementing and maintaining GE HealthCare's Command Centre Software Platform (CCSP) at a typical 500-bed hospital. The estimated 5-year cost to implement, activate, and maintain 2 to 4 GE HealthCare web-based apps, called Tiles, is between CAD $ 2-4 million, based on the number and type of Tiles in scope, the number of EMR instances involved, size of the organization, and level of activation support from GE HealthCare.

Important factors to be considered before establishing a hospital command centre

Based on our interviews with multiple sources, below is a summary of the main aspects to be considered when planning to establish a hospital command centre. We also highlight the feasibility, needs and challenges of integrating a command centre in new vs. existing hospitals

- **Cost and resources**: The costs of establishing a hospital capacity command centre include obtaining the requisite physical space, hiring staff to operate the command centre, and acquiring and maintaining the predictive analytics software. These costs are very high, particularly for existing hospitals that may need to overhaul their current systems. Within the context of our government-funded healthcare system, and given that each hospital has to coordinate with community healthcare centres (e.g. long term care facilities), the ideal scenario would be the establishment of a province-wide uniform system for command centres.
- **Setting the targets and indicators**: Each command centre can set different targets depending on the team's needs and capacity. For example, all command centres reviewed for this report had bed management as their key element, but fewer than half covered admission or case management. More than three quarters of the recent command centres also included transfer management, patient transport and environmental services.
- **Command centre physical space:** Command centres were initially conceived as a dedicated physical space bringing together multi-disciplinary teams to allow for better coordination and information flow. Ms. Zahava Uddin from GE HealthCare explained that programs use different approaches with respect to establishing physical command centre spaces. Dedicated spaces, while valuable, are not

mandatory for a successful command centre program. For some programs, the hospital-wide real-time connectedness and collaboration enabled by the command centre software enables a much smaller dedicated command centre space or no space at all. This is because the same command centre software used by central command teams is also used in a distributed way by caregiver teams on inpatient units, in clinical departments, by roaming staff, and by functions that are not centralized. It would be easier to dedicate a physical space for a command centre when building a new hospital.

- **Data infrastructure:** An essential component for a command centre is to have a data infrastructure that integrates various data sources for projecting real-time data. It would not be an issue for hospitals with full-scale electronic medical records.
- **Interface ability of different software:** Currently, in Quebec, there is no ministerial directive for all hospitals/healthcare facilities to use the same software. Ideally, the network communicates with the same information system or platform to facilitate coordination with other healthcare facilities.
- **Disruptiveness:** This would be less of an issue for hospitals with full-scale electronic medical records. The overall post-implementation experience in all centres was positive. With careful planning, process mapping, and simulation, the transition could be done smoothly. A backup procedure should be anticipated for any system failure.
- **Change in culture:** All studies and correspondents highlighted that acceptance of cultural change and strong commitment from hospital staff and management are important for the success of their command centres. In addition, a governance structure must be in place, with an emphasis on care management in addition to clinical aspects.

CONCLUSIONS

- There are no RCTs to date evaluating the efficacy of capacity command centres (CCC). All pre-post design studies (i.e., before and after CCCs establishment without control) demonstrated improvement in various indicators such as ED boarding, length of stay, transfer time, ambulance and ED diversion, and patient satisfaction. However, there is a lack of standardized indicators to evaluate the performance of CCCs.
- Experiential data from several established hospital capacity command centres in the US and Canada indicated that the integration of such systems has had an impact on better patient experience and hospital efficiency.

- The cost of establishing CCCs varies based on the need for physical space, the number and type of prediction software, the number of EMR instances, the size of the organization, and the level of activation support from the software provider.
- In addition to cost, important factors to be considered in establishing a command centre include the setting of key targets and indicators, data infrastructure, interface ability of different software, and disruptiveness.
- Finally, all studies and correspondents highlighted the importance of cultural change and strong commitment from staff and management to ensure the success of their command centres. A solid governance structure is necessary to establish policies for tracking and sustainability.

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CONTEXTE

Bien qu'il n'existe pas de définition consensuelle, les centres de commandement pour la gestion de la capacité (« centres de commandement ») des hôpitaux désignent des unités physiques et interfonctionnelles qui impliquent i) la colocalisation de groupes de travail interdisciplinaires qui exercent une influence importante sur le cheminement des patients (par exemple, les services d'admission, la gestion des lits et des transferts, et les services environnementaux); ii) l'utilisation de données en temps réel intégrées à partir de sources, dont les dossiers cliniques informatisés; et iii) la gestion d'au moins deux processus liés au cheminement des patients (par exemple, les services d'admission, la gestion des lits, la gestion des transferts interhôpitaux, le transport des patients et les services environnementaux). Un autre aspect essentiel des centres de commandement est l'utilisation de l'intelligence artificielle et de l'apprentissage automatique pour les analyses prédictives et les systèmes de notation.

Ces centres devraient contribuer à désengorger les hôpitaux grâce à leur efficacité accrue du cheminement des patients, de la gestion des lits et de l'accès aux données. L'un des principaux facteurs qui ont une incidence sur le cheminement des patients est l'attente d'usagers qui nécessitent un niveau de soins alternatif (NSA), c'est-à-dire « qui continuent d'occuper un lit dans un établissement même [s'ils] ne requièrent plus les ressources et les services qui y sont fournis ». De même, les statuts NSA peuvent entraîner un débordement des urgences et une augmentation des coûts. Une solution pour réduire le nombre d'usagers en attente d'un NSA consiste à gérer le cheminement des patients par l'intégration de divers systèmes de soins de santé documentés et par la projection de ceux-ci dans des tableaux de bord de données en temps réel et de modèles mathématiques afin de comprendre et de prévoir ce cheminement (autrement dit, des centres de commandement).

En septembre 2021, l'équipe de soutien à la transformation de la direction des projets majeurs d'infrastructures (DPMI) du CISSS de la Montérégie-Ouest (CISSS-MO) a demandé à l'Unité d'évaluation des technologies de la santé (UET) d'évaluer la faisabilité d'un centre de commandement du cheminement des patients dans le futur hôpital de Vaudreuil-Soulanges, au Québec. L'établissement, dont les travaux devraient se terminer en 2026, comptera 404 lits et plus de 3 200 employés. Il s'agira d'un hôpital « intelligent », c'est-à-dire entièrement numérique, pour fournir des soins optimisés et sécuritaires.

OBJECTIFS

Le présent rapport vise à évaluer les points suivants :

- la faisabilité et la valeur clinique d’un centre de commandement pour la gestion du cheminement des patients et de la capacité en lits de l’hôpital;
- le coût de la mise en place et de l’exploitation d’un tel centre.

MÉTHODES

Revue de la littérature

Nous avons réalisé une revue exploratoire sur les centres de commandement à partir d’une recherche dans PubMed et dans la base de données d’évaluation des technologies de la santé (HTA Database) du Centre for Reviews and Dissemination.

Coûts

Nous avons obtenu des estimations des coûts pour la mise en place d’un centre de commandement auprès de Zahava Uddin, la directrice générale du logiciel Command Centre de GE HealthCare.

Expérience au CUSM et ailleurs

Nous avons pris connaissance de l’expérience du Centre universitaire de santé McGill (CUSM) et d’hôpitaux qui disposent de centres de commandement par des correspondances, des entretiens ou des séances d’information avec les personnes suivantes :

- le D^r Frederic Dankoff, coordonnateur médical de la gestion des lits et du cheminement des patients pour le CUSM (à propos des pratiques actuelles au CUSM);
- le D^r Marc Beique, urgentologue, et directeur des TI au Département de médecine d’urgence, au CUSM;
- Mona Maalouf, gestionnaire à l’Infocentre-Performance, Direction de la qualité, de l’évaluation, de la performance et de l’éthique (DQEPE) au CUSM;
- John Fletcher, conseiller cadre, analyse et valorisation des données, à la DQEPE du CUSM;
- Jim Scheulen, directeur général du centre de commandement Judy Reitz de l’hôpital Johns Hopkins à Baltimore, au Maryland;
- Monica Stone, administratrice principale de projets à l’hôpital Johns Hopkins;
- Lise Vaillancourt, ancienne directrice de l’efficience organisationnelle à l’hôpital Montfort, à Ottawa, en Ontario;
- Carolyne Crowley, directrice du Carrefour Santé Aline-Chrétien (CSAC);
- Joanne Coté, directrice de la qualité, de la transformation, de l’évaluation, de la performance et de l’éthique au Centre intégré universitaire de santé et de services

sociaux (CIUSSS) du Centre-Ouest de Montréal (à propos du centre de commandement de l'Hôpital général juif);
- Gordon Peckham, directeur principal des opérations du centre de coordination des soins à la Régie de la santé de la Nouvelle-Écosse, Doris Grant, directrice principale de l'innovation à la Régie de la santé de la Nouvelle-Écosse, et Jonathan Veale, chef de la conception au ministère de la Santé et du Mien-être de la Nouvelle-Écosse.

RÉSULTATS

Revue de la littérature

- Nous avons ciblé 14 centres de commandement aux États-Unis et 2 au Canada dans 12 études (11 études observationnelles et 1 revue d'étude) et 9 rapports, communiqués de presse, magazines et articles de revues professionnelles (figure 1). Tous ces centres ont la gestion des lits comme élément principal. Dix impliquent la gestion des transferts (62,5 %), neuf le transport des patients et le système de services environnementaux (56,3 %), sept les services d'admission (43,8 %) et cinq la gestion de cas (31,3 %).
- Huit centres de commandement ont utilisé les indicateurs d'accueil à l'urgence (50 %). Sur une période de un à cinq ans après leur mise en œuvre, tous ces centres ont montré une diminution du temps d'accueil. D'autres ont fait état d'une amélioration de divers indicateurs tels que la durée du séjour, le volume et la durée des transferts, le détournement des ambulances et des urgences, et la satisfaction des usagers. On a également observé une performance accrue des organisations (par exemple, une diminution du nombre d'appels téléphoniques par affectation de lit/placement de patient, des formulaires papier utilisés, et de la longueur des rapports du personnel de coordination des services d'admission en fin de service, de même qu'un accroissement du cheminement des patients par le signalement plus rapide des sorties par les gestionnaires de lits).
- Il n'existe pas d'essai clinique randomisé sur l'efficacité des centres de commandement ni d'étude comparative (toutes les études sont limitées par un plan expérimental pré et post-test, c'est-à-dire avant et après la mise en place d'un centre de commandement, sans groupe de contrôle, ce qui nous empêche de comparer simultanément les centres de commandement avec d'autres stratégies. De plus, il n'existe aucun indicateur normalisé pour évaluer la performance de ces centres. Ainsi, comme indicateur de performance de la gestion des transferts, certains centres ont indiqué le temps médian de prise en charge par l'ambulance, tandis que d'autres ont indiqué le temps de transfert entre la répartition et la prise en charge ou depuis un autre établissement. Ce caractère hétérogène limite la généralisabilité des résultats.

Données expérientielles

Plusieurs hôpitaux au Canada et aux États-Unis ont mis en place des centres de commandement pour faciliter le cheminement des patients. En général, ces centres ont eu une incidence sur les points ci-dessous.

- Patients : les centres de commandement améliorent l'expérience des usagers parce qu'ils accélèrent le processus de prestation des soins, ce qui accroît la qualité, la rapidité et la sûreté des soins.
- Professionnels de la santé : les centres de commandement améliorent la communication ainsi que l'efficacité des flux de travail.
- Administrateurs d'hôpitaux : les centres de commandement renforcent l'efficacité, la responsabilité et l'amélioration continue des hôpitaux.
- Système de soins de santé : les centres de commandement accroissent l'efficacité du système au moyen de données en temps réel entre les établissements de santé du réseau, ce qui améliore la gestion des transferts.

Coûts

- Zahava Uddin, directrice générale du logiciel Command Centre de GE HealthCare, a expliqué les composantes et les coûts de la mise en œuvre et de la maintenance de la plateforme logicielle dans un hôpital type de 500 lits. Le coût estimé sur 5 ans pour la mise en place, l'activation et la maintenance de 2 à 4 applications Web de GE HealthCare, des « tuiles », se situe entre 2 et 4 millions de dollars canadiens, selon le nombre et le type de tuiles, le nombre d'instances d'archives médicales informatisées, la taille de l'organisation et le degré de soutien de la part du fournisseur lors de l'activation des logiciels.

Points importants à prendre en compte avant de mettre en place un centre de commandement

Nous résumons ci-dessous les principaux points à prendre en compte lors de la planification d'un centre de commandement en milieu hospitalier, selon nos entretiens avec plusieurs ressources. De plus, nous soulignons la faisabilité, les besoins et les défis de l'intégration d'un tel centre dans les nouveaux hôpitaux par rapport aux établissements existants.

- **Coûts et ressources :** les coûts pour la mise en place d'un centre de commandement pour la gestion de la capacité d'un hôpital comprennent l'obtention de l'espace physique requis, l'embauche de personnel, ainsi que l'acquisition et la maintenance du logiciel d'analyse prédictive. Ils sont très élevés, en particulier pour les hôpitaux existants qui peuvent devoir mettre à niveau leurs systèmes actuels. Dans le contexte de notre système de soins de santé financé par le gouvernement, et compte tenu du fait que chaque hôpital doit coordonner ses activités avec celles des centres de soins de santé communautaires (par exemple, les établissements de soins de longue durée), le scénario idéal serait l'établissement d'un système uniforme de centres de commandement à l'échelle de la province.

- **Objectifs et indicateurs :** chaque centre de commandement peut se fixer ses propres objectifs selon les besoins et les capacités de l'équipe. Par exemple, tous les centres que nous avons examinés dans le cadre de ce rapport avaient pour élément principal la gestion des lits, mais moins de la moitié impliquaient les services d'admission ou la gestion de cas. Aussi, plus des trois quarts des centres récents comprennent la gestion des transferts, le transport des patients et les services environnementaux.
- **Espace physique :** on a initialement conçu les centres de commandement comme un espace physique qui rassemblent des équipes pluridisciplinaires pour faciliter la coordination ainsi que l'acheminement de l'information. Zahava Uddin, de GE HealthCare, a expliqué que les programmes utilisent des approches différentes en ce qui concerne l'établissement d'espaces physiques pour les centres de commandement. Ces espaces dédiés, bien que précieux, ne sont pas nécessaires au bon fonctionnement d'un tel programme. Pour certains programmes, la connectivité et la collaboration en temps réel au sein de l'hôpital, grâce au logiciel du centre de commandement, permettent de réduire considérablement l'espace dédié au centre, voire de ne pas l'utiliser du tout. En effet, les équipes de soins dans les unités de patients hospitalisés, les services cliniques, le personnel itinérant et les fonctions qui ne sont pas centralisées utilisent, au même titre qu'un système réparti, le même logiciel que les équipes de centres de commandement. D'autre part, il est plus facile de dédier un espace physique pour un centre de commandement lors de la construction d'un nouvel hôpital.
- **Infrastructure de données :** une composante essentielle d'un centre de commandement est une infrastructure de données qui intègre diverses sources pour projeter des données en temps réel. Ce ne serait pas un problème pour les hôpitaux qui disposent d'archives médicales complètement informatisées.
- **Capacité d'interface de différents logiciels :** actuellement, le Québec ne dispose d'aucune directive ministérielle qui oblige tous les hôpitaux et établissements de santé à utiliser le même logiciel. Idéalement, le réseau communique avec le même système d'information ou la même plateforme pour faciliter la coordination avec les autres établissements.
- **Caractère perturbateur :** ce ne serait pas un problème pour les hôpitaux qui disposent d'archives médicales complètement informatisées. L'expérience

globale a été positive après la mise en œuvre dans tous les centres. La transition peut se faire en douceur avec une planification minutieuse, une cartographie des processus et des simulations. Il faudrait prévoir une procédure de sauvegarde en cas de défaillance du système.

- **Changement de culture :** toutes les études et tous les correspondants soulignent que l'acceptation du changement culturel et la forte participation du personnel hospitalier et de la direction ont une incidence sur l'efficacité des centres de commandement. En outre, il faut établir une structure de gouvernance qui met l'accent sur la gestion des soins et sur les aspects cliniques.

CONCLUSIONS

- Il n'existe pas d'essai clinique randomisé sur l'efficacité des centres de commandement. Toutes les études qui disposent d'un plan expérimental pré et post-test, c'est-à-dire avant et après la mise en place d'un centre de commandement, sans groupe de contrôle, démontrent une amélioration de divers indicateurs tels que l'accueil à l'urgence, la durée du séjour, le temps de transfert, le détournement des ambulances et des urgences, et la satisfaction des usagers. Toutefois, il n'existe aucun indicateur normalisé pour évaluer la performance de ces centres.
- Les données expérientielles de plusieurs centres de commandement aux États-Unis et au Canada indiquent que l'intégration de ces systèmes a eu une incidence sur l'amélioration de l'expérience des usagers et de l'efficacité des hôpitaux.
- Le coût pour la mise en place de ces centres varie en fonction du besoin d'espace physique, du nombre et du type de logiciels de prédiction, du nombre d'instances d'archives médicales informatisées, de la taille de l'organisation, et du degré de soutien de la part du fournisseur lors de l'activation des logiciels.
- En plus des coûts, l'établissement des objectifs et des indicateurs clés, l'infrastructure de données, la capacité d'interface des différents logiciels et le caractère perturbateur figurent parmi les autres facteurs importants à prendre en compte pour la mise en place d'un centre de commandement.
- Aussi, toutes les études et tous les correspondants soulignent l'importance du changement culturel et la forte participation du personnel hospitalier et de la direction pour assurer l'efficacité des centres de commandement. Une structure solide de gouvernance est nécessaire pour la mise en œuvre de politiques de suivi et de viabilité.

LIST OF ABBREVIATIONS

ADT	Admissions, Discharges, and Transfers
AI	Artificial Intelligence
ALC	Alternate Level of Care
BMD	Bed Management Dashboard
C4	Care through Communication, Collaboration and Creation)
CCCs	Capacity Command Centres
ED	Emergy Department
EMR	Electronic Medical Record
EMS	Emergency Medical Services
EVS	Environmental Services
HAL	Hopkins Access Line
HRH	Humber River Hospital
HM	Hôpital Montfort
ICU	Intensive Care Unit
JHH	John Hopkins Hospital
JRCC	Judy Reitz Command Centre
LOS	Length of stay
RTDC	Real-time Demand Capacity
RWE	Real Word Evidence
TAU	MUHC Technology Assessment Unit

The Feasibility and Clinical Value of Establishing Hospital Capacity Command Centres

1. BACKGROUND

1.1 Rationale for a Hospital Capacity Command Centre

1.1.1 Hospital overcrowding

Hospital overcrowding has long been an issue within our healthcare system, and has recently reached a breaking point in hospitals across Canada due to a perfect storm of factors accelerated by the COVID-19 pandemic: a shortage of healthcare workers, surgery backlogs, postponed treatments and an overwhelmed primary care system. Emergency department (ED) capacity in Quebec averaged at 125% in the last week of October 2022. Average ED capacity was 141% in Montreal, 200% at the Montreal Children's Hospital (1), 165% per cent at the Montreal General, and 218% at the Royal Victoria Hospital (2).

The Organisation for Economic Co-operation and Development (OECD) reported that in 2020, Canada ranked 17th among 27 countries with an average hospital length of stay by diagnostic categories of 10 days (vs. 5.3 days for 1st ranked Norway). In 2021, Canada ranked 31st among 34 countries for acute-care capacity, with 1.97 beds per 1,000 inhabitants, while Japan ranked first with 7.74 beds (3).

A leading cause of ED overcrowding i.e. being occupied beyond capacity, is inpatient 'boarding' or holding admitted patients until a hospital bed becomes available. Hospital bed availability in turn depends on patients in alternate levels of care (ALC) or "users waiting for ALC", a term used for a patient who "is occupying a bed in a facility and does not require the intensity of resources/services provided in that care setting" [CIHI, n.d.]. Users waiting for ALC mostly include (1) hospitalized patients aged 80 or over and those with certain health problems, such as major cognitive impairment, diabetes with complications or a mental health disorder; (2) patients who require referral to various outpatient services (e.g., occupational therapy, speech therapy, physiotherapy) or those who feel isolated and lack social support. Hence, the causes of ALCs may include social isolation, inadequate social services, delays in discharge planning, and insufficient beds in rehabilitation and long-term care facilities (4).

Approaches for reducing the number of users waiting for ALC include (4):

(1) improved governance (ALC-related responsibilities need to be adequately defined and distributed across national, regional, and local levels);
(2) increased financing (e.g., to increase the efficiency of hospital services, or to support home or community services); and
(3) improved flow management (e.g., integrating various documented health care systems and projecting them into dashboards that present both real-time data and mathematical models that can be used to understand and predict patient flow).

Improved flow management is the objective of hospital capacity command centres.

1.1.2 Bed management and patient flow

Bed management is a crucial aspect of managing patient flow, reducing overcrowding and improving hospital efficiency. However, this process can often be ineffective and inefficient because of fragmented communication and the need to consult multiple software systems. For e.g., a bed manager/ coordinator may need to access numerous applications/software and coordinate with many people through phone calls, text messaging, overhead pages, and emails to collect data and make decisions regarding bed assignments; a time-consuming and complicated process.

1.1.3 Data management and output issues

A centralized electronic system or dashboard that displays data in real-time would allow units to coordinate better and facilitate the transfer of patients from and to the hospital or from one unit to the other (5). Often, such information is siloed and unsynchronized, leading to the loss of valuable data and delays.

1.2 What is a Hospital Capacity Command Centre?

Institutions have recognized the need to improve patient flow management to reduce ED boarding and crowding to improve the quality of care and safety of the patients.

In the past decade, many hospitals started implementing capacity command centres (CCCs), which have long been used in the airline industry and the military to enhance situational awareness and coordinate operations. There are different terminologies, including hospital command centre, real-time health system, clinical operation centre, as well as patient flow management, and there is no consensus definition of hospital CCCs. Franklin et al. proposed CCCs as “physical and cross-functional units involving (i) co-location of interdisciplinary workgroups exerting significant influence over patient flow (e.g., admissions, bed management, environmental services, transfer management, etc.), (ii) use of real-time data integrated from sources including electronic health records, and (iii) management of two or more processes related to patient flow (e.g., admission services, bed management, interhospital transfer management, patient transport, environmental services, etc" (5).

Another important characteristic of CCC is the use of artificial intelligence and machine learning for predictive analytics and scoring systems. These systems analyze integrated data from multiple automated systems and display essential information representing the input, throughput, and output variables of the interdependent components of patient care in real-time. Hence, they enable timely and strategic operational efforts using pre-established standard operating procedures.

All the above characteristics enable the use of objective and holistic data to help make quick strategic decisions for prioritizing care delivery. Among others, they help to determine which patients are more severe and which have an actual discharge barrier; shorten wait times and hospital stays; optimize transportation operations; align scheduling for patients who need multiple diagnostic tests (laboratory and/or imaging) and treatments to assure they are administered on time.

1.3 Request from CISSS-MO

In September 2021, TAU received a request from Ms. Marie-Ève Lefebvre from the Transformation Department of the direction des projets majeurs d'infrastructures (DPMI) of the CISSS de la Montérégie-Ouest (CISSS-MO; the integrated health and social services centre of the west Monteregie region of Quebec, which includes 3 hospitals that serve a population of 488,121 people). Given the challenges mentioned above, including inefficient bed and data management, the requestors wanted to evaluate the feasibility and clinical value of establishing a hospital command centre at a new 404-bed hospital to be constructed within their territory (Vaudreuil-Soulanges) in 2026.

The CISSS de la Montérégie-Ouest falls within the McGill RUISSS (Integrated University Health Network), and the clinical value of command centres was a pertinent question of interest to MUHC stakeholders; TAU therefore agreed to accept the request.

2. POLICY AND EVALUATION QUESTIONS

2.1 Policy Question

Should the new hospital in Vaudreuil-Soulanges establish a Capacity Command Centre?

2.2 Evaluation Questions (Objective of this report)

1. What is the feasibility and clinical value of establishing a Capacity Command Centre to manage hospital patient flow and bed capacity?
2. What is the cost of establishing a Capacity Command Centre?

3. METHODS

3.1 Literature Search

We conducted a scoping review on capacity command centres by searching PubMed and the health technology assessment (HTA) database of the Centre for Reviews and Dissemination. We conducted a systematic search from inception until April 4th, 2022, using the following keywords: ("command center*" OR "bed management" OR "patient flow management" OR "real-time health system*" OR "clinical operation center*"). We excluded articles about crisis OR incident command centres, non-English articles, and articles without full-text. Our review was not limited to any specific study design. We also manually searched the reference lists of included studies and relevant electronic articles about hospital command centres.

We defined CCC as (a) co-location and/or management of two or more processes related to patient flow, AND (b) use of real-time data integrated from sources including electronic health records, OR (c) use of predictive analytics.

3.2 Experience at the MUHC and Elsewhere

Experience at the MUHC and hospitals with established command centres was obtained through correspondents, interviews or information sessions with the following people:

- Dr. Frederic Dankoff, MUHC Medical Coordinator for Bed Management and Patient Flow, to describe current practice at the MUHC, where a command centre currently does not exist;
- Dr. Marc Beique, Emergency Medicine Physician and Emergency Department IT Director, MUHC;

- Mona Maalouf, Infocentre-Performance Manager, Direction of Quality, Evaluation, Performance and Ethics (DQEPE), MUHC;
- John Fletcher, Executive Advisor, Data Analysis and Valorization, DQEPE, MUHC;
- Jim Scheulen, Chief Administrative Officer of the Judy Reitz Command Center of the Johns Hopkins Hospital, Baltimore, Maryland;
- Monica Stone, Senior Project Administrator of the Johns Hopkins Hospital;
- Lise Vaillancourt, former director of hospital performance at the Montfort Hospital, Ottawa, Ontario;
- Carolyne Crowley, Director of the Carrefour Santé Aline-Chrétien Health Hub (CSAC);
- Joanne Coté, director of quality, innovation, and performance at the West-Central Montreal's Centre Integré Universitaire de santé et de service sociaux (CIUSSS) about the Jewish General Hospital's command centre.
- Gordon Peckham, Senior Director for Care Coordination Centre Operations at Nova Scotia Health, Doris Grant, Senior Director for Innovation at Nova Scotia Health and Jonathan Veale, Chief Design Officer at the Nova Scotia Department of Health and Wellness.

3.3 Cost Analysis

We obtained the estimated cost breakdown of establishing a Capacity Command Centre through an interview and correspondence with Ms. Zahava Uddin, the Managing Director of GE Healthcare Command Center.

4. RESULTS

4.1 Results of the Literature Search

We identified 12 studies (11 observational, one review), and nine report, press release, magazine, or trade journal articles (Figure 1). There are no RCTs to date evaluating the efficacy of CCCs. Table 1 displays an overview of 14 hospital capacity command centres in the US and 2 in Canada. Bed management is the key element in all centres. Transfer management was covered in 10 (62.5%) while patient transport and environmental system (EVS) in 9 (56.3%) CCCs.

4.1.1. Electronic bed management systems

We identified five early CCCs in the US established before 2010 (6-10), that were essentially bed management dashboards. None include case management and only 1 in 5 (20%) covered transfer management, transport, and environmental system.

- Rosow et al. described the launch of the Bed Management Dashboard (BMD) at **Hartford Hospital** in **Connecticut** in April 2001 (6). They acknowledged that manual patient flow management using paper, whiteboards, and phone calls caused a lack of accurate and real-time information to match bed availability with patient clinical needs. “This causes inefficient use of beds, resources and provider time, leading ultimately to reduced throughput; ED crowding; lost admissions; operating room delays; unhappy physicians, staff, and patients; decreased revenue; and higher expenses.” BMD streamlines the process of admitting, transferring, and discharging patients by connecting all departments (e.g., admission, emergency department, operating room, intensive care unit, administration) on a 24/7 basis. It allows administrators, clinicians, and managers to easily access, analyze, and display real-time patient and bed availability information, which results in timely data-driven decisions.

- Tortorella et al. (9) described how to improve the bed turnover component of the patient throughput process by implementing an electronic bed management system to enhance communication between the multiple disciplines involved in facilitating patient flow at the **University of Texas MD Anderson Cancer Center**. A bed management team composed of frontline employees, clinicians, educators, and administrative staff, evaluated the obstacles and causes for admissions, discharges, and transfers (ADT) delays. The absence of a consistent system to share and verify information caused inefficiency because the same information was handled multiple times or lost altogether. The centre also did not have the tools to capture and share discharge and room status information to enable efficient bed turnover. The team collaborated with the information technology (IT) department to generate an electronic bed management system (BMS) to track inpatient room status and communicate this vital information to housekeeping, patient transportation, admissions, and nursing. Implementing BMS decreased bed turnover time and improved the overall patient throughput process.

- Jweinat et al. described the step-by-step process of the Safe Patient Flow initiative at **Yale-New Haven Hospital** (YNHH) in Connecticut.(10) YNHH transformed its patient flow processes, management systems, and behaviors across all clinical and ancillary areas between July 2008–September 2012. They engaged an outside consulting firm to collect extensive baseline data on patient flow through time-and-motion observations and data analysis. Subsequently, internal and external consultants developed process maps to reveal how patients moved throughout YNHH, how staff documented and performed their daily tasks, and how physicians provided care. They detected inefficiencies in the system, process, and procedures. Accordingly, they worked together with the staff to develop process changes. In executing the changes, they use a vendor-provided bed management system to centralize the hospital's bed management process, including bed turnover and patient flow. The system collects numerous data to provide a single source for patient flow information. In addition to engaging digital technology, they gave financial incentives to reward all employees when specific, measurable, hospital-wide goals were met at the end of each fiscal year.

4.1.2. More comprehensive command centre systems

A systematic review by Franklin et al. identified seven more recent CCCs in the US (Table 1) (11-19). We also identified two more CCCs in the US (20-23) and two CCCs in Canada (24-27). AdventHealth Mission Control is by far the largest in the US with a 12,000-square-foot command centre that serves 18 EDs, including 11 hospitals, and individually tracks between 2,400 and 2,600 patients everyday [22]. All recent CCCs not only focus on bed management, but also case management (45.5%), transfer management (81.8%), patient transport and environmental system (72.7%).

4.1.3. Impact of capacity command centres on performance indicators

Table 2 summarizes the impact of capacity command centres. All reported uncontrolled comparisons of the pre-post establishment of their CCCs. Eight (50%) CCCs used ED boarding indicators. All showed improvement in ED boarding time. Others reported improvement in various indicators such as length of stay, transfer volume and time, ambulance and ED diversion, and patient satisfaction. Rossow et al. also demonstrated improvement in administrative performance (e.g., decreased number of phone calls per bed assignment/patient placement, paper forms used, length of the end-of-shift admission coordinator reports, and increased throughput by alerting bed managers to discharges earlier).

4.2 Main Limitations of the Studies

The studies included in this report all used different indicators to evaluate the performance of CCCs. For example, Lovett et al. (11) reported the median of environmental system (EVS) response and turnaround time while Tortorella et al. (9) only reported the latter and other centres with EVS components did not report any EVS indicators. Texas Children's Hospital (19) reported transfer time from dispatch to pick up (19); whereas NewYork-Presbyterian Hospital(16) used the time to complete a transfer from another facility as a performance indicator related to transfer management. This heterogeneity restricts the generalizability of findings. Moreover, there is no comparative study; all studies used a pre-post design (i.e., before and after CCC establishment without control), so we were unable to simultaneously compare CCCs with other strategies.

5. EXPERIENCE AT THE MUHC AND ELSEWEHERE

5.1 Current practice at the McGill University Health Centre (MUHC)

Current clinical situation

- Like all hospitals across Canada, the MUHC emergency department (ED) currently faces significant challenges in terms of overcrowding, lengthy ED wait times and prolonged length of stay. ED occupancy rates have ranged from 150% to 300% in the past year. The causes of ED overcrowding at the MUHC include but are not limited to high visit volumes to the ED, variability in doctor practice patterns (e.g., time to consulting, time to admit), nursing staffing shortages, and delays in the consultation and admission decision and processes.
- The current trajectory of a patient in the ED includes triage, nursing and medical assessment, investigations and consults, and ends with a decision to discharge or admit; bottlenecks can occur at each step. A major challenge is outflow of ED patients, because once a decision to admit a patient is made, the patient may wait in the ED for several days for in-patient beds. This hampers ED activities because it has limited capacity to board patients.
- When an over-capacity code is activated, several targeted actions are taken such as opening over-capacity beds, identifying available in-patient beds, and expediting discharges from in-patient units. However, actionable data on bottlenecks are not easily available.

Current data infrastructure and future directions

- Currently, the MUHC does not have a hospital-wide capacity command centre. ED data is sourced from a clinical application called *'Tableau des lits',* which displays real-time bed capacity on large screens. However, *'Tableau des lits'* is not an analytics tool and does not have predictive capabilities.
- A major challenge is the availability of real-time data to all stakeholders on bottlenecks (e.g. delays in radiology or ED reassessments) so that decision-makers can intervene in a timely manner.

- Pilot project:
  - The MUHC is piloting a 'Command Centre Dashboard' that aims to make real-time information available to all stakeholders, deliver actionable information to the right person at the right time, and enable data-driven and measurable cultural and process changes at the MUHC.
  - In Phase 1, the pilot project will focus on ED patient flow. Data will be harnessed from the clinical ED systems (MedUrge and Siurge) as well as the inpatient ADT systems (Clinibase) in near real-time. Data is transformed and stored on MUHC servers in InfoCentre. BI and analytics are then made available through the MUHC/MSSS Power BI Cloud platform. Visual dashboards will be made available on users' phones to solve bottleneck problems as they occur. The objective is to provide real-time data that will help decision-makers predict and detect problems and decide on actions that will improve the ED flow challenges. In Phase 2, the project will be expanded MUHC-wide to involve various departments.
  - Datasets are approached from various angles: the **status dataset** which relates to the overall situation of the ED, and includes variables such as stretcher occupancy rate and number of admitted patients waiting for a bed. The second group of datasets refers to **actionable items (**e.g. radiology delay; no. of patients with consults not started). The list of parameters included in the status dataset and actionable items is displayed in the Appendix. These are to be customized for specific groups of users: hospital and ED admin, flow coordinators, nurses in charge, physicians, consultants, etc.

5.2 The Judy Reitz Capacity Command Centre

We interviewed and corresponded with Jim Scheulen, the Chief Administrative Officer of Emergency Medicine at The Johns Hopkins Hospital in Baltimore, Maryland, USA. The John Hopkins Hospital (JHH) has 996 beds, including 134 ICU beds, 49 additional NICU beds, and 52 operating rooms, with more than 90,000 emergency visits and more than 49,000 operating cases annually.

5.2.1 Concept development

- The Judy Reitz Capacity Command Centre, known informally as C3, that Mr. Scheulen designed and implemented at his institution, is just one of several tools in the Office of Capacity Management.
- Planning for the centre began in 2014 when the simulation model was created and the design of the physical space began. Two teams worked together to develop the work performed within the capacity command centre: the command centre working

group oversaw the design of the space and workflows of the teams within C3, and a process improvement working group designed the strategic imperatives and metrics for success.

- To address practicality, feasibility, and affordability issues, JHH used a prioritization matrix to determine which problems needed solutions that would have the most significant impact on overall capacity management. Factors that drove the development of the centre included ED boarding, OR holds, as well as Hopkins Access Line (HAL) wait times, and decline rates. The working group weighed these factors against cost considerations, the magnitude of change, the cultural transformation required, and the complexity of the technical solution.
- The capacity command centre launched operations in 2016, coinciding with a health system-wide upgrade to a new electronic medical record system, which required great investments of time, technical reskilling, and training. All five JHM hospitals in the Baltimore-Washington market use this integrated system, which has several safeguards in place to ensure business continuity and data protection.

5.2.2 Operation and components of the command centre

- C3 uses a foundation of systems engineering, simulation modeling, and predictive analytics to integrate resources throughout the hospital that get the ***right patient*** into the ***right bed*** at the ***right time***. Access to real-time operational data allows co-located experts in C3 to reduce the administrative burden on the provider team by streamlining and expediting the progression of care from admission to discharge. In addition, it allows the clinical teams to focus on providing the highest quality patient care to more than 40,000 inpatient admissions each year.
- Data pulled from existing systems of orders, including staffing and the electronic medical records system (common to all entities within the Johns Hopkins Health System), are integrated and analyzed by the prediction and logic engine. It was designed in conjunction with GE Healthcare, which developed the model under an initial five-year contract (now in a maintenance mode). The Wall of Analytics displays real-time data across 22 video monitors and on the web in a password-secured environment, helping the experts within the centre and working remotely across JHH to monitor conditions and make decisions.

5.2.3 Function and roles

- The experts working within the command centre support this mission through well-defined roles:
  - <u>Bed management coordinators</u>: all experienced registered nurses, facilitate the movement of adult medicine, surgery, and neurosciences patients from all entry

points to the appropriate units. They also support capacity management on a larger scale throughout the Johns Hopkins Health System by interfacing daily with clinical and administrative teams from every entity in the region (five entities).

- The Hopkins Access Line (HAL) coordinators: connect Johns Hopkins Medicine providers with medical providers across the globe, facilitating patient transfer to the hospital for expert care that they might not otherwise be able to access.
- HopComm/Lifeline: is the team that arranges transportation and provides critical care life support for both incoming patients and existing patients within the system who are transported throughout the hospital.
- Admitting: The admissions coordinators facilitate the hospital admissions and financial clearance process for all hospitalized patients, including HAL, the Emergency Department, and the operating rooms.

5.2.4 Outcomes and future directions

- Five years after its launching, indicators for bed assignment, ambulance pick up, patient transfer capacity from other hospital, patient transfer post-surgery all showed improvements (Table 2).

- Key leaders of the original teams continue to meet monthly with advisory committees, including clinical directors and hospital executives. Major hospital-wide initiatives that have been led by the department using command centre data include: aligning patient discharges to anticipated demand for beds, improving patient placement practices, maintaining high levels of perioperative throughput, monitoring length of stay reduction initiatives, and increasing access for urgent admissions and transfers into The Johns Hopkins Hospital. Future strategic goals for the capacity management team include developing a more integrated approach to resource management across the entire health system rather than just within JHH. Additionally, Mr. Scheulen plans to build an infrastructure that will apply C3's data modeling and analytics to monitor quality and safety data, supporting improved patient outcomes

5.3 The Humber River Hospital Command Centre

In Canada, Humber River Hospital (HRH) in Toronto is the first hospital to run a CCC (Table 1) (24), and it was declared "North America's first fully digital hospital" (28). In a documentary video (25), Barbara Collins, CEO of HRH, explained that the new HRH was opened in 2015 with 615 beds and serves 850,000 patients.

5.3.1 Operation and components of the command centre

- The 4,500-square-foot command centre was launched in 2017 to manage patient flow. It has a wall of 25 tiles with constant updating screens, measuring everything from bed availability to housekeeping, as well as some cameras of the ED and the waiting rooms to see if they are busy or not. Currently, 15-20 people work in the flow of patients.
- The command centre uses real-time data, advanced algorithms, and predictive analytics to provide an overview of patient flow at the hospital, emergency patient volume, bed allocation and assignments, room cleaning, critical care capacity, surgical and diagnostic scheduling, and discharge planning. Moreover, it helps identify and resolve bottleneck problems so the patient's care process can run smoothly. The objectives are to optimize staffing, reduce cancellations and length of stay, and reduce costs. As a result, it helped improve patient experience: 4 years in a row 2016/17 until 2019/20 HRH ranked first on global patients experience by the Canadian Institute for Health Information (Table 2). In 2018, HRH earned Accreditation with Exemplary Standing from Accreditation Canada (29).
- The command centre incorporates the National Early Warning Score (NEWS) algorithm from the Royal College of Physicians, UK (2017) into the vital sign monitors that a frontline nurse or care provider uses when monitoring blood pressure, temperature, oxygen level and other vital signs of each patient. Once a nurse takes a patient's vital signs, they can 'save' the vital sign information and 'send' it to a patient's electronic medical record for documentation. This way, the NEWS 2 scores and clinical action can be incorporated across their electronic system platforms to alert physicians and nurses about the patient's overall physiological status and risk – and used during shift handoff reports to ensure continuity of care. For example, a high NEWS 2 score can identify patients with sepsis or those at risk of clinical deterioration.

5.3.2 Function and roles

The HRH Command Centre has progressively incorporated the following functions over three generations (up to June 2017):

- Phase-1: Patient flow and patient care logistics. It co-locates staff who coordinate patient admissions, including the bed allocation clerk, patient flow manager, homecare manager, support services supervisor, medical imaging flow technologist, operating room schedulers, and nursing resource team manager.

- Phase-2: Clinical pathway and care maps using predictive analytics to identify patient needs. It was a new concept that HRH developed with GE Healthcare. The command centre allows them to monitor patients' progress through the care maps and intervene when there is a problem.
- Phase-3: Home monitoring for discharged patients who need monitoring or assistance at home. This function of the command centre allows HRH to link to that patient through wearable technology or telephone. HRH can connect with community providers to have them check the patients, bring them back to the elective clinic, and help manage the patient so they can stay at home longer than going to the ED.

5.4 The Jewish General Hospital's Command Centre

The CIUSSS Centre-Ouest-De-L'Île-De-Montréal (CCOMTL) is the first organization in the province of Quebec to implement a CCC called the C4 (Continuum of care, Collaboration, Communication and Creativity) at the Jewish General Hospital. It gathers and displays data from an integrated healthcare network comprising multiple sites managed by multiple directorates (1). Joanne Coté, the director of quality, transformation, value, clinical ethics and Virtual Care, presented that the vision is to provide care everywhere needed within the network, and the main goal is to ensure patients are getting the right care, at the right place, at the right moment by the right professional. The C4 can oversee and expedite patient flows and transfers within West-Central Montreal's CIUSSS.

5.4.1 Concept development

- Although the patient flow policy of the JGH was launched in March 2017, the preparatory work for developing a command centre to improve hospital flow was started in May 2020 by involving senior clinical management and medical leadership. The objective was to enhance the fluidity of patient trajectories to facilitate access, reduce delays, and ensure the delivery of high-quality care and patient-centreed service while meeting departmental and organizational targets.(2)
- From May to December 2020, a process-mapping exercise was conducted with 90 different clinical groups. Between December 2020 and February 2021, during the 3rd wave of the COVID-19 pandemic, a working group of senior managers from all clinical departments was brought together in a temporary command centre to develop the vision, mission, and priorities. The C4 operations were launched in March 2021, with patients waiting for ALC (Alternate levels of Care) as the

priority. In October 2021, C4 continued to operate with the waiting list and length of stay as the priorities.

- The team emphasized that successful implementation of a command centre relies on committed and mobilized management, physicians and clinical teams; a focus on culture change; an inter-departmental partnership; a culture of data; and communication.
- The command centre now has a dedicated budget from the institutional operating budget including 3 bed managers.

5.4.2 Operation and components of the command centre

- The C4 command centre partners with Maisha Labs and uses artificial intelligence (AI) algorithms to predict length of stay, discharge estimates, and patient volume and flow through the emergency department
- On the C4 dashboards, hospital and CIUSSS-level data are refreshed every 15 minutes. Alerts are displayed on the screen based on CIUSSS thresholds. This process provides the management/leadership insights about bottlenecks and external events that may impact operations.(3)
- Information displayed on the dashboards was developed in consultation with the clinical teams, and the displayed data can be modified as needed. The emergency room dashboards can drill down to the patient
- The CCOMTL C4 team stated that physical proximity is an essential element for the proper functioning and creation of a dynamic in the command room (importance of presence to increase the accessibility of crucial people before and after meeting and becomes a rallying point)(3).

5.4.3 Function and roles

- The C4 command centre has two portions:
  - Twice a day meetings focussed on the three following themes: Alternate levels of care, patient flow and medical flow in the emergency room involving all the admitting services. In the morning and afternoon, various department coordinators meet to check numbers and patient flow and observe the changing data throughout the day.
  - Working groups for specific problems (e.g. mental health).
- Representatives of several CIUSSS directorates—such as Nursing, SAPA: Long-Term Care and Home Care, Rehabilitation—also sit at computer terminals, where they work closely with managers to oversee the daily flow of patients.

5.4.4 Outcomes and future directions

- Two years after its launch, the JGH team reported improvements in ED, ALC, and psychiatric care indicators (Table 3) in period 7 of the 2021-22 fiscal year compared to the same period in 2019-20, which reflect the impact of cultural change of the organisation, the accountability of the clinical directorates involved and the fluid communication that is now embedded.
- Although these improvements were less marked in period 7 of the 2022-23 fiscal year, the indicators were still better than before the C4 era:
  - (i) ED indicators: delay in admission from ED to a ward decreased from 31.1 hours to 28.3 hours, and the use of the overcapacity protocol decreased dramatically from 152 to 3 times.
  - (ii) The median daily number of patients waiting in ALC declined from 67 patients to 61.4.
  - (iii) The waiting list for mental health service decreased from 734 to 602 adult patients. The length of stay also declined from 25.6 to 20.0 days.
- Changes in the more recent performance indicators could be partially explained by the new Health Ministry policy implemented since summer 2022, which allows ALC status to be declared in the home environment. Mme. Coté added that, "Weekly, JGH has an average of 40-50 new declared ALC, which indicates the vulnerability and frailty of our users and demonstrates how resourceful our teams are. We also lost 250 LTC beds on our territory, which impacted access to long term care beds beyond our territory as they are managed centrally via a *guichet d'accès (*point of access*).*"
- In fiscal year 2021-22, the JGH also launched virtual wards (home hospital) (Table 3). Using smartwatches and patches from Biobeat to remotely monitor patients who may be at high risk for complications, physicians can remotely intervene in these patients to prevent an emergency department visit or hospitalization, which helps free up hospital beds. Up to period 9 2022-2023, there were 139 patients had been cared for in the virtual ward, indicating a savings of 1008 days of presence in the hospital because patients were cared for at home virtually.

5.5 Hôpital Montfort

Hôpital Montfort in Ottawa, Canada is a 300 bed-hospital and serves 300,000 patients annually.

5.5.1 Concept development

- Lise Vaillancourt, the former director of hospital performance, who also worked on expansion and fluidity projects of Hôpital Montfort, explained that they started implementing a Lean approach to improve the efficiency of the emergency department at the end of 2008. In 2014 and 2018, it earned Accreditation with Exemplary Standing from Accreditation Canada .
- The Patient Flow command centre was established in response to the COVID-19 pandemic, when they realized that being all in one space and receiving real-time information made coordination of patient flow management more efficient.

5.5.2 Operation and components of the command centre

- Hôpital Montfort is a paperless hospital. It does not work with a vendor for data integration and prediction analytics.
- The hospital uses Meditech for their EMR (it is similar to EPIC EMR). They utilize hybrid equipment:
    - Nurses work with Workstation on Wheels (WoW) or 1 computer per nurse;
    - Physicians make notes on file on tablets or use fixed computers at the workstations or corridors.
    - Physicians write electronic prescriptions, validated by the pharmacist on the unit who updates the electronic medication administration form (formulaire d'administration des médicaments [FADM]).
    - Pharmacists work with laptops (because the system is too slow on the tablet). Zebra smartphones are used as barcode readers for drug administration (bar coding Medication verification). The Scanner Control App enables Zebra cordless scanners to communicates with the FADM/PC on the WoW.
    - The Director of Professional Services has a clinical informatics staff to monitor charting, so that the process is fast, automatic and intuitive, and works to facilitate the tasks of clinical teams.
    - Patient chart (connected care) MyChart is accessible by the patients (i.e., they have access to most of their file from their home).
    - Patients will have access to an entertainment system in 2022-2023, where each patient will have a TV with entertainment. They will be able to order food, view clinical info before discharge, answer surveys, etc.

5.5.3 Function and roles

- The command centre includes a flow manager and coordinator, admissions bed manager, staffing, porters (stretcher) manager, infection control, physician manager, and discharge management.
- The flow manager has four screens that display information from the emergency and admission databases. Their goal is to have patients stay less than 24 hours in the emergency department. When there are five patients awaiting hospitalization in the emergency department, a flag will be raised, and bed management meeting will be held to find solutions (escalation protocol). With this early intervention, HM now has the best emergency wait time improvement in the Capital Region and is in the top third in Ontario for admitted and non-admitted patients.
- Each housekeeping staff has a route and an iPad to indicate when a room or task is completed. This enables tracking of tasks and staffing needs. The stretcher bearers communicate by walkie-talkie with headset. Some upstream works were done to facilitate the movement of personnel and the spirit of collaboration. For example, involving unions to adjust the job descriptions.

5.5.4 Future directions

Ontario is the only province that does not yet have an Integrated Health and Social Services Centre (*Centre intégré de santé et de services sociaux* [CISSS]). Montfort Hospital is partnering with Bruyère CHEO, Eastern Ottawa Resource Centre, Geriatric Psychiatry Community Services of Ottawa, Home and Community Care Support Services Champlain, ParaMed, and Youth Services Bureau of Ottawa in the implementation of the Orleans Health Hub, which recently changed to Carrefour Santé Aline-Chrétien Health Hub (CSAC)(31). This Hub was opened in June 2021 and is a prototype for healthcare improvement across Ontario that will improve access to coordinated healthcare services. A collaborative electronic platformwith Calian and registration tool have been established for the providers of specialized and community care, medical imaging, as well as rehabilitation, mental health, and senior service programs to offer both physical and virtual services. Nonetheless, partners will still have their own documentation system for individual management purposes.

5.6 Care Coordination Centre (C3) in Nova Scotia (32)

5.6.1 Concept development

- After five months of preparation, Nova Scotia Health (NSH) launched its Care Coordination Centre (C3) in 2022 to transform patient access and flow across the system.
- As the first province-wide healthcare command centre in Canada serving 42 hospitals once fully implemented, C3 combines a new physical operations centre located at the Halifax Infirmary site of the QEII Health Sciences Centre with hospital-wide use of GE Healthcare's Command Centre Software Platform (CCSP) and a revamped set of standard operating procedures (SOPs).
- The CCSP technology aims to put high value, high-quality, real-time insights generated from existing source systems in the hands of inpatient unit teams, department teams and C3 staff, for better awareness of actions needing prioritization, better decisions and better connectedness and collaboration.

5.6.2 Operation and components of the command centre

- Specifically, six apps (known as "Tiles") focused on the aspects below are being rolled out approximately every two months and integrated into daily operations at the QEII initially, followed by the hospitals in the rest of the Central Zone and rest of the province:
    - bed capacity,
    - care progression and discharge planning,
    - patients waiting for beds,
    - patients transferring from other hospitals,
    - ED length of stay and
    - surgical capacity
- New and refreshed operating procedures and routines are continuously in development, to support process change, culture change, use of technology and actions triggered by new real-time situational awareness.

5.6.3 Function and roles

- The C3 team is comprised of roles such as patient flow managers (i.e. for acute, continuing care, heart health, mental health and other), the bed allocator, emergency health services liaison, transfers liaison, and others.

- They collaborate and problem solve with patient care teams across the hospital to expedite care activities, remove bottlenecks and redeploy staff to mitigate capacity and other pressures.

5.6.4 Targeted outcomes and future directions

- The goals for Nova Scotia Health's C3 program are simple and clear:
    - Remove the stress of day-to-day work away from front-line caregiver teams by putting useful information at the fingertips of staff that are accountable to make decisions.
    - This enables patient care to occur efficiently, effectively and quickly, thereby benefitting patients with faster, better patient care.
- The impact to the system will be tracked by measuring conservable bed days, the percent of ED patients with length of stay over 12 hours, the percent of patients on acute units with length of stay over 26 days, and acute inpatient unit occupancy levels. The collaboration with GE Healthcare to implement this first generation of Nova Scotia Health's C3 program is three years.

6. COST

There are several Healthcare Command Centre software suppliers, including GE HealthCare (at Humber River Hospital and Nova Scotia Health) and Maisha Labs (at Jewish General Hospital). Below, we summarize GE HealthCare's software platform and associated costs.

6.1 GE Command Centre Software and Associated Costs

6.1.1 The cost components

Ms. Zahava Uddin, Managing Director, GE HealthCare Command Centers, explained the components and costs of implementing and maintaining GE HealthCare's Command Center Software Platform (CCSP) at a typical 500-bed hospital.

- The CCSP provides a common digital thread that is used to automate and streamline the care team's daily operating system of integrated rounds, huddles, and prioritization practices. This enables inpatient units, departments and central command staff to work in sync as they coordinate, expedite and problem-solve care delivery at the patient, department and hospital-wide levels in real-time.
- GE HealthCare's CCSP is vendor agnostic and integrates data elements from any source system, including EMRs (Epic, Cerner, Meditech, etc.) and other workflow

systems (Teletracking, Kronos, Steris, etc.), into a single data model. It processes the data using purpose-built algorithms to produce high-value insights, which are then consumed in real-time by charge nurses, allied health, patient flow managers, imaging leads and other leaders via intuitive web-based apps called Tiles.

- CCSP is supported on an ongoing basis and includes technical support with a 24/7 help desk, software updates and interface updates.
- Program components include software licenses, CCSP implementation and activation services, program governance, CCSP support and maintenance, collaboration with GE HealthCare's command centre ecosystem (>250 hospitals using CCSP) and if applicable, developing and operationalizing a new central command function, ongoing cloud hosting services and video wall implementation and support.
- The estimated 5-year cost to implement, activate, and maintain 2 to 4 GE HealthCare Tiles is between CAD $ 2-4 million, based on the number and type of Tiles in scope, the number of EMR instances involved, size of the organization, and level of activation support from GE HealthCare.
- Up-front costs are lower, and recurring annual costs higher with a subscription purchase compared to a capital purchase, enabling organizations to get started with less capital outlay. Central command design, GE HealthCare managed cloud hosting via MS Azure or other and video wall implementation are optional and may be added as part of a comprehensive program with additional cost.

6.1.2 Operationalizing the 'Tiles' (Apps)

- Implementing Tiles involves configuring for local preferences, data mapping, building interfaces, training and deployment.
- Operationalizing Tiles in everyday practice involves defining and putting into practice action sets, protocols, and accountabilities. It also includes tuning the Tiles by using user-defined profiles that create curated patient lists with real-time information about the patient and the status of activities needed to progress their care. Profile views directly support the specific workflows of each care provider (e.g., a charge nurse might use a profile that instantly shows all her patients with an expected discharge date, plus a discharge disposition of home with supports, plus an unread CT and/or pending lab order).
- Operationalizing Tiles as part of the work done by the central command team involves developing procedures triggered by alert states on the Tiles, new escalation protocols that support the front line and accountability structures that drive clear and timely action to remove delays and barriers, and mitigate risks.

6.1.3 Recommended 'Tiles'

When resources are limited, Capacity Expediter (CE) and Patient Manager (PM) are strongly recommended as the two foundational Tiles for implementation. They complement each other very well:

- Capacity Expediter provides a valuable view of bed status and availability by considering expected incoming/outgoing patients.
- Patient Manager is a multi-purpose Tile that supports care progression and discharge planning by providing a useful view of patient status, progression, needs, risks, etc., that can be tuned to any individual user or team's needs.

Capacity Expediter Tile:

- This Tile would be useful for bed management and patient flow coordinators because it provides automated real-time information on current status of all beds, including the number of patients waiting to be assigned a bed and patients yet to be unassigned a bed but needing one.
- Access to such real-time data would help with decision-making, for example regarding prioritization of discharges, resources need to be deployed/surged and beds to be unblocked.
- The Capacity Pressure Indicator in Capacity Expediter Tile provides a real-time, hospital-wide view of where pressure is building and is used to trigger surge protocols and other actions to decongest capacity.
- The Staffing Module for Capacity Expediter Tile may be added to provide high value insight about staffing barriers and opportunities with respect to available capacity, by inpatient unit, level of care, program, etc.

Patient Manager Tile:

- This Tile visualizes real-time patient-level alerts, risk scores, pending, context-relevant intelligence, and the plan of care to provide a holistic view of the patient. It includes context-rich flags, alerts and algorithms to support care progression and discharge planning activities.
- This Tile is useful during rounds, huddles, shift handovers, and other aspects of daily patient care to facilitate decision-making about the expected day of discharge, discharge barriers, readmission risks, etc. It could help reduce avoidable excess days, LOS, and barriers to post-acute placement by triggering earlier action (e.g., expediting a CT, arranging a post-discharge follow-up appointment, etc.).

7. DISCUSSION

7.1 Factors Affecting Patient Flow

A systematic review by Winasti et al. (33) grouped factors affecting patient flow into four categories:

- variability of patient arrivals (i.e., physician preference and decisions to refer patients to certain centres),
- insufficient resources in designated units,
- ineffective inter-unit interactions, and
- delays in inpatient discharge for non-medical reasons (i.e., patients waiting for ALC).

Overcrowding in emergency units is dependent on the designated inpatient occupancy. When there are insufficient resources in the designated inpatient units, patients who are medically ready for discharge from the ER must wait until beds are available, while new patients arrive. Poor inter-unit coordination can cause missing shared information regarding real-time demand and bed availability, which obstructs patient flow.

The above issues are in accordance with an INESSS evaluation(4) that patients waiting for ALC could be the source of overcrowding in the emergency unit. Command centres that operate within an established health care and social service network such as a CISSS and CIUSSS in Quebec can address this issue by overseeing and expediting patient flow and transfers within the network, as done by the C4 command centre of the Jewish General Hospital in Montreal.

The biggest challenge for the MUHC or other centres without an integrated health care and social service centre would be to ensure communication with the external facilities (i.e., local community service centres [CLSC], residential and long-term care centres [CHSLD], and private residences for seniors [RPA]). The MUHC can learn from the Aline-Chrétien Health Hub initiative in Ontario province to overcome this problem. They established a partnership between seven distinct healthcare and community organizations using an electronic platform to provide specialized and community care through physical and virtual services.

7.2 Summary of the Evidence for Impact on Clinical Outcomes

Evidence from the literature, based on pre-post capacity command centre (CCC) studies, indicates an improvement in a variety of key hospital performance indicators ranging from decreased ED boarding time, ambulance and ED diversion due to ED overcrowding to shorter length of stay without jeopardizing the quality of care. However, the uncontrolled design of these studies and the heterogeneous results lower the quality of these findings.

A number of hospitals in Canada and the US have established command centres to facilitate patient flow. In general, they have found that command centres have an impact on: (11-15, 24, 26)

- patients: command centres improve patient experience by accelerating the process of care delivery, which in return result in better, faster, and safer patient care
- healthcare professionals: command centres enhance communication and improve workflows efficiency
- hospital administrators: command centres enhance hospital efficiency, accountability, and continuous improvement
- the health care system: command centres provide a more efficient system by enhancing transfer management using real-time data between healthcare facilities within the network.

7.3 Aspects to be Considered to Establish a Command Centre

Table 4 highlights the feasibility, needs and challenges of integrating a command centre in new vs. existing hospitals.

7.3.1 Cost and resources

- The costs of establishing a hospital capacity command centre include obtaining the requisite physical space, hiring staff to operate the command centre, and acquiring and maintaining the predictive analytics software. These costs are very high, particularly for existing hospitals that may need to overhaul their current systems.
- Within the context of our government-funded healthcare system, and given that each hospital has to coordinate with community healthcare centres (e.g. long term care facilities), the ideal scenario would be the establishment of a province-wide uniform system for command centres.

7.3.2 Setting targets and indicators

- Each command centre can set different targets depending on the team's needs and capacity. For example, all command centres reviewed for this report had bed management as their key element, but fewer than half covered admission or case

management. More than three quarters of the recent command centres also included transfer management, patient transport and environmental services.
- The C4 command centre of the Jewish General Hospital started by targeting improvement in patients waiting for ALC because it was including all the clinical directorates and data most accessible). Nonetheless, standardized guidelines or criteria need to be developed for some processes. For example, they needed to develop specific standards to determine whether a patient would be ready for discharge or the frequency of consults for psychiatric patients before discharge.

7.3.3 Command centre physical space

- Command centres were initially conceived as a dedicated physical space bringing together multi-disciplinary teams to allow for better coordination and information flow.
- The CCOMTL C4 team stated that physical proximity is an essential element for the proper functioning and creation of a dynamic in the command room (importance of presence to increase the accessibility of crucial people before and after meeting and becomes a rallying point).
- Nonetheless, Mme Vaillancourt of Hôpital Montfort emphasized that the culture in which everyone works collaboratively as a team (physicians, admission, patient transport, housekeeping, etc.) is more important than having an actual physical co-location.
- Ms. Zahava Uddin from GE HealthCare noted that command centre physical spaces have clear value in co-locating a central team to coordinate, prioritize, and solve problems across different functions and roles using command centre software displayed on a video wall and at workstations. Some dedicated command centre spaces are (>5,000 ft^2), accommodating many functions, roles, and facilities (e.g., EMS coordination, patient transfers, home, and community care, OR scheduling, staff scheduling, virtual care), whereas others are much smaller (<2,000 ft^2) and focus on centralizing patient flow, transfers and bed management. In either case, the work that happens in the command centre physical space is directly connected with the work on the front lines, resulting in faster, and better quality patient care.
- Ms. Uddin stressed that programs use different approaches with respect to establishing physical command centre spaces. Dedicated spaces, while valuable, are not mandatory for a successful command centre program. For some programs, the hospital-wide real-time connectedness and collaboration enabled by the command centre software enables a much smaller dedicated command centre space or no space at all. This is because the same command centre

software used by central command teams is also used in a distributed way by caregiver teams on inpatient units, in clinical departments, by roaming staff, and by functions that are not centralized.

- In general, it would be easier to dedicate a physical space for a command centre when building a new hospital.

7.3.4 Data infrastructure

- An essential component for a command centre is to have a data infrastructure that integrates various data sources for projecting real-time data. It would not be an issue for hospitals with full-scale electronic medical records.

7.3.5 Interface ability of different software

- Currently, in Quebec, there is no ministerial directive for all hospitals/healthcare facilities to use the same software. Ideally, the network communicates with the same information system or platform to facilitate coordination with other healthcare facilities. For example, the command centre of the Jewish General Hospital operates within West-Central Montreal's CIUSSS. The command centre at Johns Hopkins has the same operating system as its five sister hospitals.

7.3.6 Disruptiveness

- This would be less of an issue for hospitals with full-scale electronic medical records.
- The overall post-implementation experience in all centres was positive. With careful planning, process mapping, and simulation, the transition could be done smoothly.
- A backup procedure should be anticipated for any system failure.

7.3.7 Change in culture

- Establishing a command centre should not be treated as an IT project but rather as a change in organizational culture and process. Initially, there would be some hesitancy and resistance towards the new practice from the personnel.
- Hence, all references and correspondents highlighted that acceptance of cultural change and strong commitment from hospital staff and management are important for the success of their command centres.
- In addition, a governance structure must be in place, with emphasis on care management in addition to clinical aspects. For example, the Yale-New Haven

Hospital transformed not only its patient flow processes but also its management systems and behaviors across all clinical and ancillary areas. They involved the staff in identifying the problem and developing process changes. They also reward all employees when the hospital-wide goals are met (10).

8. CONCLUSIONS

- There are no RCTs to date evaluating the efficacy of capacity command centres (CCC). All pre-post design studies (i.e., before and after CCCs establishment without control) demonstrated improvement in various indicators such as ED boarding, length of stay, transfer time, ambulance and ED diversion, and patient satisfaction. However, there is a lack of standardized indicators to evaluate the performance of CCCs.
- Experiential data from several established hospital capacity command centres in the US and Canada indicated that the integration of such systems has had an impact on better patient experience and hospital efficiency.
- The cost of establishing CCCs varies based on the need of physical space, number and type of prediction software, the number of EMR instances, the size of the organization, and the level of activation support from the software provider.
- In addition to cost, important factors to be considered in establishing a command centre include the setting of key targets and indicators, data infrastructure, interface ability of different software, and disruptiveness.
- Finally, all studies and correspondents highlighted the importance of cultural change and strong commitment from staff and management to ensure success of their command centres. A solid governance structure is necessary to establish policies for tracking and sustainability.

FIGURE

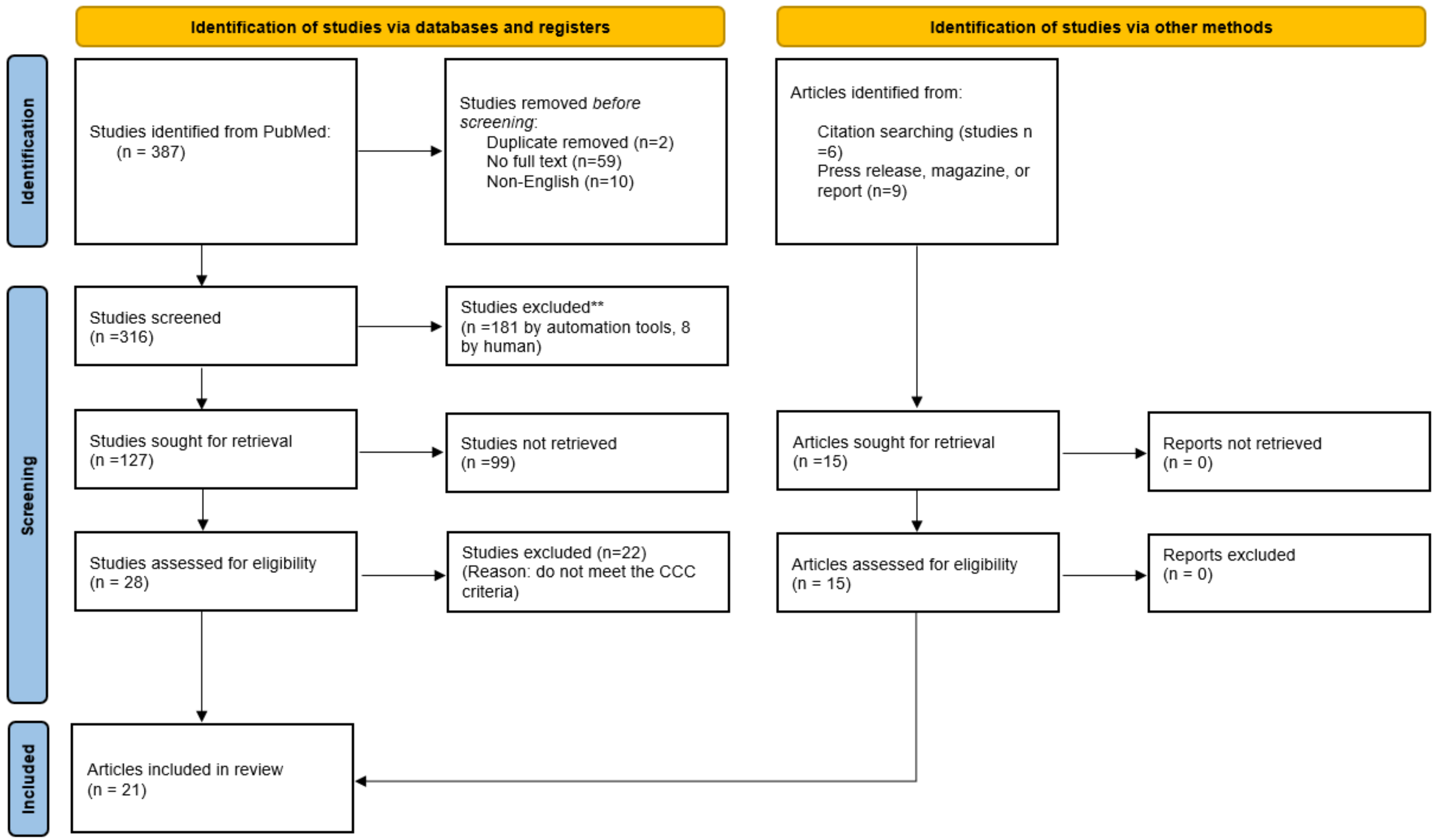

Figure 1. PRISMA flowchart of the literature

TABLES

Table 1. Characteristics of Capacity Command Centres

Article	Publication Type	Study Design	Hospital or Health System (No. Hospitals Managed by CCC)	Date CCC Opened	Functions Co-located in CCC					Interventions Implemented Concurrently With CCC Deployment	Vendor (Budget)
					Admission	Bed mngmt	Case mngmt	Transfer mngmt	Patient transport, EVS		
Rosow (2003)	Peer-reviewed journal	Uncontrolled pre-post study	Hartford Hospital, Connecticut, US (864-bed tertiary care hospital)	Apr 2001	√	√				It has more than 900 trained users and can be accessed on the more than 3,500 workstations throughout the organization. The system is interfaced to the hospital's ADT information system (Siemens/SMS), pagers, phones, and email	N/A
Hemphill (2005)	Peer-reviewed journal	Uncontrolled pre-post study	The Access Center of the Saint Francis Hospital, Oklahoma, US (a tertiary care hospital and trauma centre, regional referral centre)	2004	√	√		√		Identifying service line capacity with bed status color codes Adding a bed management coordinator Expediting bed assignments and minimizing ED diversionary status	N/A
Resar (2009)	Peer-reviewed journal	Uncontrolled pre-post study	University of Pittsburgh Medical Center (UPMC), Pittsburgh, US (an academic tertiary care hospital with 526-bed, 70 ICU beds and 20 separate units)	2007		√				Real-time demand capacity management (RTDC) standard processes: Predicting Capacity, Predicting Demand, Developing a Plan, and Evaluating a Plan—and standard structures for unit bed huddles and the hospital bed meetings were developed	N/A
Tortorella (2013)	Peer-reviewed journal	Uncontrolled pre-post study	University of Texas MD Anderson Cancer Center (a 631-bed tertiary cancer centre)	September 2008	√	√			√	Implementing an electronic Bed Management System (BMS) to track inpatient room status and communicate this vital information to housekeeping, patient transportation, admissions, and nursing	No vendor

Article	Publication Type	Study Design	Hospital or Health System (No. Hospitals Managed by CCC)	Date CCC Opened	Functions Co-located in CCC					Interventions Implemented Concurrently With CCC Deployment	Vendor (Budget)
					Admission	Bed mngmt	Case mngmt	Transfer mngmt	Patient transport, EVS		
Jweinat (2013)	Peer-reviewed journal	Uncontrolled pre-post study between FY 2008 and FY 2012	The Safe Patient Flow Initiative of the Yale-New Haven Hospital (YNHH), Emergency Medicine, Connecticut, US (3) A primary teaching hospital with 966-bed (2008). YNHH included the Yale-New Haven Children's Hospital, Smilow Cancer Hospital, and Yale-New Haven Psychiatric Hospital.	Oct 2008		√				Engaging an outside consulting firm to collect extensive baseline data on patient flow through time-and-motion observations and data analysis; developed process maps to fully reflect how patients moved throughout YNHH, how staff documented and performed their daily tasks, and how physicians provided care. Vendor-provided bed management system (which included bed turnover and patient flow). Visual Controls for Clinically Ready Discharges with color-coded discharge plan; Employee Performance Incentive Plan (PIP) that provides a financial incentive to all employees if specific, measurable, hospital wide goals are met at the end of each fiscal year.	N/A
Lovett et al (2016)[a]	Peer-reviewed journal	Uncontrolled pre-post study	Patient Flow Management Center of the Jefferson Health, Philadelphia, US	2011		√	√	√	√	Immediate bedding, bed assignment algorithms, transfer of low-acuity patients to community campus, telemetry rationalization, daily bed planning huddle, RTDC management	GE Healthcare
Morris et al (2015)[a] **Davenport et al (2018)**	Peer-reviewed journal	Uncontrolled pre-post study	Carilion Clinic	2012		√	√	√	√	Daily patient placement and operations huddle	N/A
Chan (2017)[a] **Kane (2019)**	Peer-reviewed journal	Uncontrolled pre-post study	New Office of Capacity Management of the **Johns Hopkins Hospital**	2016	√	√		√	√	Predictive and prescriptive analytics to guide command centre staff (e.g., bed placement), simulation modeling to test impact of proposed improvement projects (e.g., impact of inpatient bed reallocation on ED Boarding)	GE Healthcare
Advisory Board Company (2016)[a]	Trade journal	N/A	Patient Placement Operations Center (PPOC) of the **NewYork-Presbyterian** (NYP)/Columbia University Medical Center, US	2016		√		√	√	Command centre staff analyzes trends in metrics (data driven practice)	N/A

Article	Publication Type	Study Design	Hospital or Health System (No. Hospitals Managed by CCC)	Date CCC Opened	Functions Co-located in CCC					Interventions Implemented Concurrently With CCC Deployment	Vendor (Budget)
					Admission	Bed mngmt	Case mngmt	Transfer mngmt	Patient transport, EVS		
Brassfield (2018) [a]	Magazine	N/A	**Texas Children's Hospital**, US (3 hospital campuses with 745-bed hospital system that admits more than 30,000 patients and handles 122,000 emergency department visits per year)	2017	√	√		√		Not reported	Budget $1.285 million, 3,500-square-foot facility)
Fox (2018) [a]	Analyst report	N/A	Mission Control Center of the Oregon Health and Science University, US (3)	2017		√		√		Not reported	GE Healthcare (N/A)
TCA Regional News (2019) [a]	Press release	N/A	Phoebe Care Command Center of the Phoebe Putney Memorial Hospital, US	2019		√			√	Predictive analytics and innovative problem-solving	$2.5 million investment, hiring more than 30 employees to help staff the centre
Tampa General Hospital	Press Release	N/A	Tampa General Hospital CareComm manages the flow of 1,007 bed academic medical centre	2019		√	√	√	√	Predictive analytics (20 artificial intelligence apps, or "tiles"). New Departure Lounge to further improve patients' experience and patient flow. Instead of waiting in their hospital room to receive their take-home medicine or for their ride home, patients are now able to go to the lounge.	GE Healthcare (N/A)

Article	Publication Type	Study Design	Hospital or Health System (No. Hospitals Managed by CCC)	Date CCC Opened	Functions Co-located in CCC					Interventions Implemented Concurrently With CCC Deployment	Vendor (Budget)
					Admission	Bed mngmt	Case mngmt	Transfer mngmt	Patient transport, EVS		
AdventHealth	Press Release	N/A	AdventHealth Mission Control The 12,000-square-foot command centre serves 18 EDs, including 11 hospitals, and individually track between 2,400 and 2,600 patients everyday	2019		√		√	√	They combine a complex real-time data to forecast capacity and use artificial intelligence to inform and guide decision-making in areas including ambulance and helicopter dispatch, patient transfers between units and facilities, and prioritization of placement and treatment	GE Healthcare (N/A)
Collins (2021)	Peer-reviewed journal	N/A	Command Centre of the Humber River Hospital, Toronto, Canada Serving a population of more than 850,000 people with over 700 beds, almost 5,000 employees, 700 physicians and >1,000 volunteers	Nov 2017	√	√	√		√	Command Centre – Generation 1 – Access and Flow infrastructure by implementing the input–throughput–output model Command Centre – Generation 2 (CC2) –applying the five principles of high reliability and using predictive analytics	
JGH News (2021)	Press Release, Presentation	N/A	C4 command centre (Care through Communication, Collab oration and Creation) of the CIUSSS West-Central Montreal (Covers a total of 34 healthcare facilities and services)	2021	√	√	√	√		Predictive analytics software; infection prevention and control; rehabilitation, mental health, home care and long-term care, telehealth. A virtual ward pilot project for cardiology patients. Using smartwatches and patches from Biobeat, the hospital is able to remotely monitor patients who may be at high risk for complications.	Maisha Lab

[a] Included in the meta-analysis by Franklin et al (5)

EMS, emergency medical services; EVS, environmental services; LOS, length of stay; mgmt, management; N/A, not available; NSA (Niveau des soins alternatif): patients who no longer require active care, but are waiting to be transferred to a rehabilitation centre, long-term care centre, home care or other facility); NYP, NewYork-Presbyterian; OR hold, circumstances in which postoperative patients are held in the operating room while awaiting availability of beds for their ongoing care; RN, registered nurse; RTDC, real-time demand capacity.

Table 2. Outcome Measures of Capacity Command Centres

Reference	Study Design	Impact on ED Boarding	Other Results
Rosow (2003)	Uncontrolled pre-post study	75% to 90% decrease in the overall time needed for the patient placement process	$200,000 annual expense avoidance by reducing the number of bed manager full-time equivalents needed 50% decrease in the number of phone calls per bed assignment/patient placement 50% decrease in the number of paper forms used 25% increase in throughput by alerting bed managers to discharges sooner of those that are reported to bed managers 40-minute decrease in the length of the end-of-shift admission coordinator reports
Hemphill (2005)	Uncontrolled pre-post study (data from Jan-Jun 2003 vs. Jan-Jun 2004)		Time from Bed Request to Transport decreased from 131 to 91 minutes 63% decrease in Emergency department diversionary hours (from 385 to 141 hours) Transfer requests increased by 48% (1224 in Q1 2003 to 1816 in Q1 2004) Denials due to no capacity decreased by 54% (209 in Q1 2003 to 97 in Q1 2004)
Resar (2009)	Uncontrolled pre-post study	The ED boarding time decreased from >5 hours to < 4 hours;	
Tortorella (2013)	Uncontrolled pre-post study		The overall bed turnover time decreased 56% from 111 minutes Patient transportation turnaround time was reduced to 26 minutes The median time to resolve red beds reduced 58% from 72 minutes Housekeeping turnaround time was reduced 22% from 63 minutes
Jweinat (2013)	Uncontrolled pre-post study between FY 2008 and FY 2012		The percentage of discharges by 11:00 A.M. improved by 22% The average LOS decreased from 5.23 days to 5.05 days An additional 45 inpatients were accommodated on a daily basis because of the decrease in average LOS
Lovett et al (2016)	Uncontrolled pre-post study (data from Jun 2010 to Feb 2011 vs. Apr 2011 to March 2013)	Mean ED boarding hours per month decreased by 43% from 7047 hours	• Total admissions (per month) increased by 5% from 2677 • ED visits (per month) increased by 7.7% from 4850 • Patient transport total completed jobs (per month) increased by 21.2% from 11475 • Ambulance diversion (hours per month) decreased by 92% from 86 • ED left without being seen (% of ED visits) decreased from 6.20% to 3.60% • ED door to provider time (median, minutes) decreased 55% from 74 minutes • Mean of EVS response time decreased by 42% from 77 minutes • Mean of EVS turn time decreased by 37% from 115 minutes • Mean of bed request to assign time decreased 32% from 153 minutes
Davenport et al (2018)	Uncontrolled pre-post study	From FY 2013 to FY 2015, ED boarding time remained flat	• Transfer volumes at hospital 1 increased by 3% (243 patients) in FY 2013, increased by 2% (191 patients) in FY 2014, and increased by 7% (702 patients) in FY 2015 • ICU length of stay at hospital 1 decreased by 0.3 d from FY 2013 to FY 2015

Reference	Study Design	Impact on ED Boarding	Other Results
Kane et al (2019)	Uncontrolled pre-post study	Median ED boarding time for dept of medicine inpatient beds decreased from 9.7 to 6.3 h at constant occupancy (no statistical significance value reported) Five years after its launching, patients are assigned a bed 38% faster (or 3.5 hours earlier) after a decision is made to admit them from the ED.	Comparing FY 2017 to FY 2018 (CCC launched February 2016): • Discharges before noon—medicine increased from 8.2% to 10.2% (P < 0.0001) • Discharges before noon—neurosciences increased from 12.8% to 14.4% (P < 0.0001) • Discharges before noon—Surgery decreased from20.6% to 18.7% (reported as not statistically significant) Number of OR holds* increased from 22 (January–June 2017) to 25 (July–December 2017; reported as not statistically significant) and decreased from 25 (July–December 2017) to 14 (January–June 2018) p=0.001 Five years after its launching, JHH had improved the following priorities from its matrix: **Patient transfers from other hospitals:** A 46% improvement in the ability to accept patients with complex medical conditions from other hospitals around the region and country. **Ambulance pickup:** Johns Hopkins' critical care team is now dispatched 43 minutes sooner to pick up patients from outside hospitals. **Operating room:** Transfer delays from the operating room after a procedure have been reduced by 83%. **A seamless operation:** Careful planning resulted in only limited disruption during implementation. C3's experience as the hub of capacity management has been a positive change for the organization as a whole.
Advisory Board Company (2016)	N/A		Time to admission has declined by 20% Time to complete a transfer from another facility has dropped from 24 hours to 8 hours Patient satisfaction score has improved
Brassfield (2018)	N/A		Transfer time from dispatch to pickup decreased by 20 minutes. Transports increased by 20%
Fox (2018)	N/A		Transfer patients increased 6.4% (554 more patients) Declined transfer patients reduced by 18% (92 less) Transfer acceptance increased 1% to 96% Outcomes amount to >7x return on investment (ROI)
TCA Regional News (2019)	N/A		Decreased patient wait times: reduced the average inpatients wait time for imaging services by 92%
Tampa General Hospital (2019)	N/A	ED diversion declined by 25% for the level one trauma centre that serves the entire West Coast of Florida	Decreased average length of stay by eliminating 20,000 excess days
AdventHealth (2019)	N/A	Admitted patients in the ER have gotten a bed assigned 15 minutes faster. ER admission to bed placement times decreased by over 23 minutes.	Lateral transfer of patients from one hospital to another due to overcapacity went from 357 pre-pandemic to over 2,450 — an increase of more than 600%. The phone call abandonment rate for AdventHealth's Transfer Center decreased from 8% to 3%. Transport times among interhospital transfers has decreased over 15 minutes.

Reference	Study Design	Impact on ED Boarding	Other Results
Collins (2021)	N/A		Safety and quality of care indicators: (a) infection control (30 months without ventilator-associated pneumonia (VAP), 32 months without outbreak); (b) medication errors (0.01% medication errors vs. 2.5-3.5% in the literature); and (c) patient satisfaction (4 years in a row 2016/17 until 2019/20 HRH ranked first on global patients experience by the Canadian Institute for Health Information Thirty-five additional inpatient beds have been generated since the implementation of the CC1 tiles
JGH News (2021)	N/A	Period 7 FY 2019/2020 vs. 2022/2023 a. Admission time from ED to care unit: 31.3 → 28.3 hrs b. Use of overcapacity protocol decreased by 98% (from 152 to 3 times)	Period 7 FY 2019/2020 vs. 2022/2023 1. ALC a. Decreased daily median: 67 → 61.4 patients b. Decreased mean bed occupancy rate: 11% → 7% c. Decreased mean length of stay in geriatric ward 16.4 → 15.5 days 2. Mental Health Access a. Decreased adult clientele waiting list: 734 → 602 users c. Decreased length of stay: 25.6 → 20.0 days

Where statistical significance values are not specified in this table, none were reported.

*OR holds (also known as OR exit holds) were defined as instances in which patients remained in the OR for more than 15 minutes after case completion. EVS, environmental services; ICU, intensive care unit; OR, operating room

Table 3. Outcome Measures of the CCOMTL C4 Command Centre

	P7 2019/2020	P7 2021/2022	P13 2021/2022	P7 2022/2023
ED indicators				
Delay in admission from ER to ward	31.3 hours	23.2 hours	24.1 hours	28.3hours
The use of the overcapacity protocol	152 times		6 times	3 times
ALC indicators				
Daily median	67	45	43	61.4
Mean bed occupancy rate	11%	7.0%	7.5%	10.8%
Mean length of stay - Geriatric wards	16.4 days	15.5 days	15.6 days	
Mean length of stay - Readaptation centre				
Catherine Booth		35.56 days	34.69 days	33.92 days
Julius Richardson		40.99 days	39.81 days	42.99 days
Psychiatric care indicators				
Adult clientele waiting list	734 users	331 users	645 users	602 users
Wait time for admittance from ED to ward		18 hours	10 hours	7 hours
Length of stay	25.6 days	21.2 days	19.5 days	20.0 days
Virtual ward				
Number of cases			52	
Patient day*			323 days	
Average length of stay at the virtual ward			6 days	

*The total number of days spent on the virtual wards for all patients

Table 4. Feasibility of Integrating Command Centres at New vs. Existing Hospitals

Feasibility aspects	New hospital (e.g., Vaudreuil-Soulanges Hospital)	Existing hospital (e.g., MUHC)
Dedicate a physical space	Easy	Challenging, but possible (e.g. CCOMTL C4, Montfort Hospital). A virtual CCC is an option
Allocate (hire new) staff to operate CCC	Easier	More challenging due to fixed budget
Training staff	Easy	Easy
Data infrastructure (integration of various data sources for projecting real-time data)	Can deploy hospital-wide electronic medical record with or without prediction analytic software (e.g., Montfort hospital)	Currently at the MUHC, ED data is sourced from a clinical application called '*Tableau des lits'*, which displays real-time bed capacity on large screens. However, there is no capacity to predict discharge date.
Prediction analytics software (e.g. the estimated 5-year cost to implement, activate, and maintain 2 to 4 GE HealthCare web-based apps, called Tiles, is between CAD $ 2-4 million)	Can deploy software to integrate various data sources for projecting predictions. Needs back up for software fails	Can deploy software that is compatible with existing ones. Needs back up for software fails.
Disruptiveness	Not applicable	With careful planning the transition could be smooth (experience from John Hopkins, CCOMTL C4, HRH, Montfort hospital)
Network with other facilities	Easy within a network (e.g., CISSS or CIUSSS)	Can learn from the Carrefour Santé Aline-Chrétien Health Hub (CSAC) to have an online platform communicate with the external facilities that the MUHC deals with (CLSC, CHSLD, RPA)
Culture change	Easier	More challenging for hospital-wide staff from top to bottom to be familiar with and synergize their operation with CCC

APPENDIX

The list of the planned parameters included in the MUHC 'Command Centre Dashboard'

Datasets	Parameters
Status data	Volume so far that day Total number of patients Waiting to be seen (incl. pre-triage) Stretcher occupancy rate Known discharges (home or admit) Consults pending Admitted waiting for a bed
Actionable data (numbers posted with drill-down menus)	Waiting for triage Phlebotomy request not done/delay Stretcher patients with no MD PEC Consults not aware delay Patient BIPAP, high flow, intubated or requiring specific meds (pressors, insulin drip, etc.) Stretcher patients not requiring more than 2L O_2 or isolation Discharge with transport need Amb room/ flex chairs occupied by stretcher patients Amb room occupied by same patient > 1 hour Admitted with no assigned beds Bed assigned, waiting to leave the ED – anticipated delay or > 1 hour since bed assignment Consult not started > 4 hours Consult started/requested with no decision > 6 hours Consults to specific services for ambulatory patients (could go to clinics) Admitted not requiring IV meds or oxygen. Radiology delay by type (US, CT, MRI, regular) with delay for the report (US, CT, MRI only) Delay to PEC/ by zone Patients with work-up completed Patients > 4 hours since PEC

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