

SPECIAL REPORT

STATEWIDE CRITICAL CARE COORDINATION CENTER (C4)

APRIL 7, 2022

MARYLAND INSTITUTE FOR EMERGENCY MEDICAL SERVICES SYSTEMS
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Executive Summary

Public health emergencies, like the novel coronavirus SARS-CoV-2 pandemic of 2019 (COVID-19), can cause unprecedented demand for critical care services. Here we describe statewide implementation of a critical care coordination center (C4) designed to optimize intensive care unit (ICU) utilization and to ensure appropriate healthcare resource allocation.

The transfer of patients between hospitals is a common practice in critical care medicine and tends to flow from hospitals with fewer resources to those with more advanced capabilities. Approximately 4.5% of ICU and 5.9% of non-ICU admissions in the US involve interfacility transfers, which represent close to 50,000 and over 100,000 transfers per year, respectively.^{1,2} When the interfacility transfer process is not clear or consistent, such transfers can increase inpatient mortality and healthcare costs, and also increase patients' length of stay.^{1,2,3} Due to the nature of COVID-19's rapid transmission coupled with a long course of hospitalization, Maryland experienced an increased number of ICU hospitalizations.⁴ As ICUs became full, critical care patients were boarded in hospital emergency departments—a practice that has been associated with poor patient outcomes.^{5,6,7,8} Normal interfacility transfer pathways of critically ill patients were overwhelmed. Hence, it became clear that during a pandemic—and beyond—allocation of critical care resources requires thoughtful, proactive resource management strategies.

The Maryland Institute for Emergency Medical Services Systems (MIEMSS), in response to the COVID-19 pandemic, created the Critical Care Coordination Center (C4) to facilitate critical care transfers throughout the State of Maryland. While many of the resulting transfers were to tertiary healthcare facilities, the C4 process resulted in nearly 60% of patient transfers to non-tertiary facilities, and frequently patients were able to be managed at the transfer-initiating facility with medical direction from the Central Intensivist Physician (CIP). Thus, the most sophisticated resources were reserved for patients with the most advanced needs, and resources were more evenly distributed throughout the state. In this report, we describe the characteristics of the C4 patient population, operational characteristics associated with transfers, and the relationship between hospitals' location and critical care transfers. We also describe how the C4 effectively implemented the elements of a safe and efficient interhospital transfer team to support critical care transfers throughout the state of Maryland during the COVID-19 pandemic.

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Establishing the Need for a Statewide Coordination Center

The state of Maryland, while one of the smallest states in land mass, is home to a large culturally and geographically diverse population. Described as “America in miniature” Maryland features mountains, beaches, farms, dense urban cities, and sparsely populated rural tracts. Hospital and EMS operations are equally diverse, anchored by a network of health systems that serve our citizens and those of neighboring states.

The Maryland Institute of Emergency Medical Services Systems (MIEMSS) provides oversight to Maryland’s EMS Services and hospitals. MIEMSS’ goals are to organize, standardize, promote and enhance statewide delivery of EMS care, to lead the development of emergency medical treatment based on current and evolving science, best practices and research, and to ensure hospitals that receive patients from EMS are prepared to continue with best clinical practices. MIEMSS promulgates ever evolving, standardized, statewide prehospital care protocols for EMS clinicians. This ensures the patients from the most austere points of injury or illness receive the same level of care as those in the affluent and more resourced metropolitan centers. As a public safety-based organization, MIEMSS provides accreditation, oversight and designation for well-established “hub and spoke” specialty referral centers for emergency and critical care for cardiac, trauma, stroke & perinatal care. Outlying and non-designated facilities have the ability to receive and stabilize patients. If the patient’s needs are beyond the scope of the initial receiving facility, the patient is transferred to a hospital with a higher level of care. This system is well understood and operates largely without conflict or unnecessary delay. Prior to the pandemic there had been no established protocol for interfacility transfer of critical care patients for hospital capacity. There was no well-worn path. There was no precedent, generally because there was no need, to transfer patients anywhere but to a “higher level of care.” Further, there was no system that facilitated awareness of where critical care capacity existed throughout the State outside of affiliated healthcare systems.

During the early course of the pandemic, a community hospital experience served as the motivation for the C4. The hospital was caring for more critical patients than its ICU capacity, causing several patients to board in the emergency department (ED) for days at a time. This, in turn, necessitated the hospital to “close” a disproportionate share of the ED, limiting its ability to accommodate newly arriving EMS and walk-in patients. The obvious dilemma was the capability of ED staff to manage the ICU patients for durations in excess of what was typical. The ripple effect created broad awareness. When asked, hospital leadership conveyed that they were quite capable of caring for the critical ED patients, meaning the patients were within the scope of sophistication of the ICU but the hospital was merely out of space and critical care staff. They had tried to transfer the patients to tertiary and quaternary centers, following their well-worn patterns, but that was, for the most part, unsuccessful. Those centers recognized their value in caring for the sickest of the sick. While the patients in limbo needed critical care, they didn’t need the caliber of care the would-be referral centers could provide and were keeping themselves available to deliver. Attempting to transfer a patient to a similarly-sized or neighboring hospital proved to be an arduous and time-consuming process for emergency department and staff, further limiting a clinician’s time with patients. The County / Hospital Alert Tracking System (CHATS), established by MIEMSS to provide hospitals with a method of alerting EMS clinicians to overcrowding and limited critical care beds, provided little relief in geographically isolated parts of the state where rerouting of EMS was geographically unavailable. The challenge was immediately apparent. The C4 was established to solve those problems.

While Maryland had an established statewide emergency operations center (SEOC) administered by the Maryland Department of Emergency Management (MDEM) for disasters including weather events and civil disturbances, a critical event as sustained and exhaustive as the COVID-19 pandemic had never been experienced in Maryland’s history. To meet the challenging demands and needs of hospitals as the

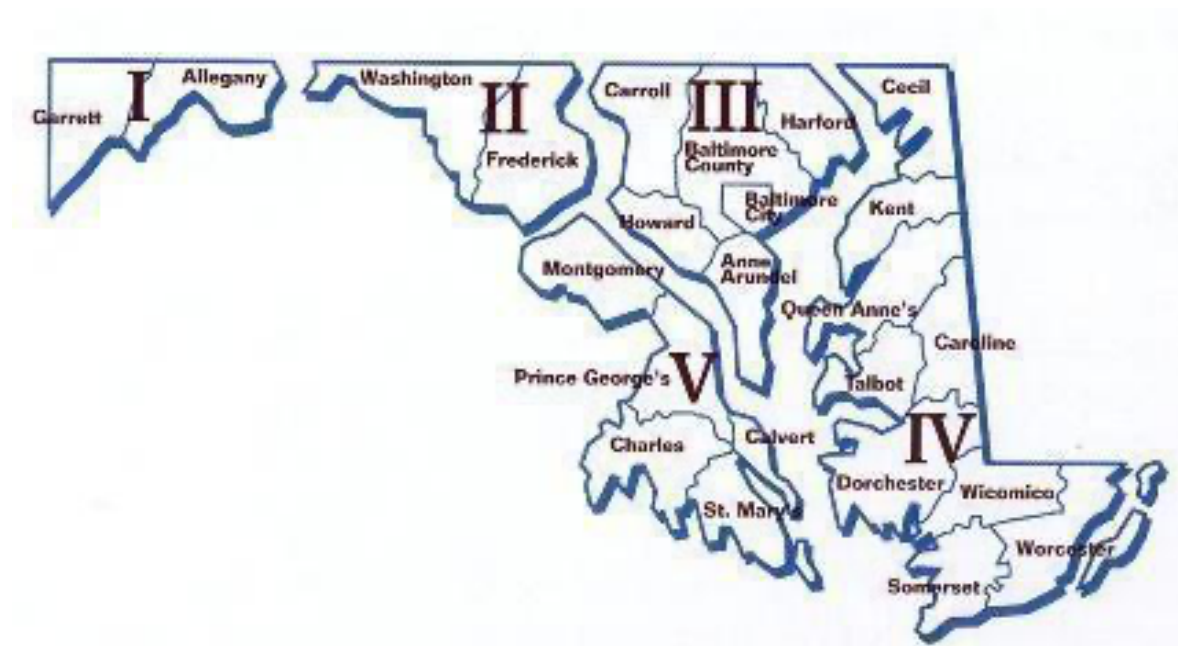
pandemic evolved, MIEMSS executive leadership determined it was necessary to create a centralized resource for hospitals to access critical care beds and resources. MIEMSS consulted with forward thinkers from the University of Maryland to develop the concept and establish the protocols to begin facilitating patient transfers. The Governor and his executive staff were briefed and enthusiastic at its prospects.

The C4 was designed to supplement Maryland's pre-existing model "to ensure the right patient gets to the right care at the right time." The concept's inception began as a 24 hour call center, staffed with an experienced, board-certified central intensivist physician (CIP) and an advanced life support licensed prehospital clinician (clinical coordinator), to provide clinicians across the state with immediate access to medical direction, statewide bed availability, and transfer coordination assistance. C4 team members would screen intake call requests, determine patient acuity and specialty care needs, and provide clinical and administrative support to hospitals with capacity and specialty request transfers. It was believed that the implementation of the C4 was necessary to bridge the access gap caused by the COVID-19 pandemic and mitigate the increasingly limited capacity of statewide ICU beds, associated critical care resources, and overwhelming of hospital emergency departments.

Maryland EMS Regions

Maryland is divided into five regions that are coordinated for monitoring, assisting and guiding the operation of the EMS system in the area. MIEMSS regions support local response efforts during large-scale incidents and liaise with other health partners throughout the state (Figure 1).

Figure 1. Maryland EMS regions

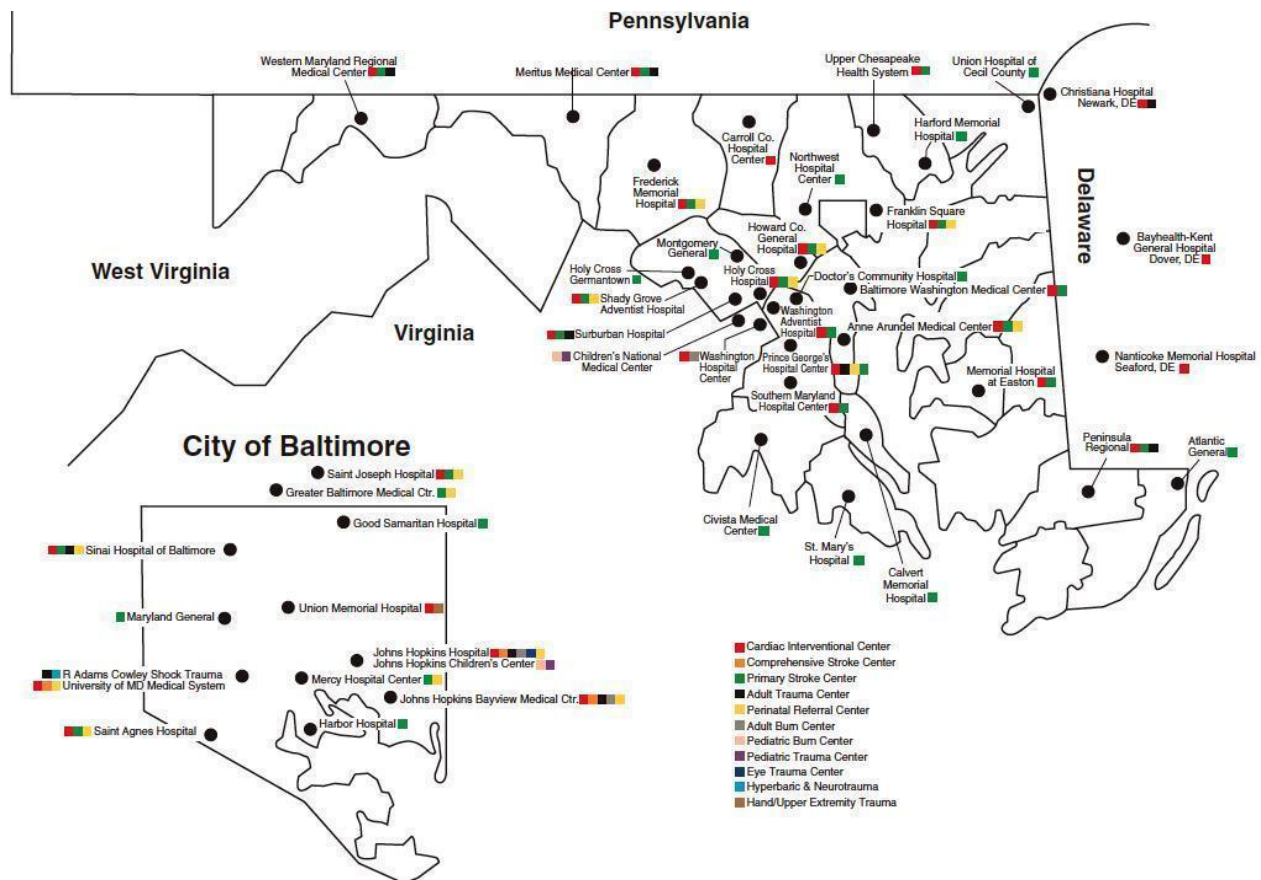


Maryland's Hospital Network

Maryland has 55 acute care facilities and specialty referral centers including 4 in Regions I and II, 24 in Region III, 6 in Region IV and 21 in Region V. From these a total of 22 are designated Cardiac Intervention Centers (CIC), 34 are designated stroke centers, 8 are trauma centers, 15 are perinatal centers and 2 have the expertise to handle burn patients (Figure 2). An additional challenge identified by the

COVID-19 pandemic was that critical care specialties and procedural abilities of community & non-tertiary hospitals remained widely unknown. This problem was identified, addressed and overcome during the course of C4 operations. C4 coordinators determined that keeping a more-comprehensive list of the critical care capabilities of non-tertiary hospitals allowed for improved proactive management of patient destination and further reduced the strain on tertiary & quaternary care facilities.

Figure 2. Map of Maryland hospitals denoting trauma & specialty referral centers



Out-Of-State Interfacility Transfers

Due to the unique geography of Maryland and the location of acute care facilities in relation to population distribution, it is unrealistic to consider our state “in a vacuum.” As such, establishing the C4 required fostering relationships with numerous out-of-state centralized bed coordination centers and independent hospitals in addition to in-state facilities. We are uniquely the only statewide critical care access resource among Maryland’s surrounding states, and we routinely assist out-of-state hospitals with their own placement requests. The C4 recently began receiving international repatriation requests, an additional critical care situation not previously considered before its’ inception.

Implementation & Critical Care Transfer Operations

Bolstered by the declared state of emergency and need to act with vigor, as soon as the initial protocols were established and expert intensivists were recruited from leading hospitals throughout the state, the C4 began operating on November 30, 2020 based at MIEMSS headquarters in Baltimore, adjacent to the statewide EMS Systems Communications (SYSCOM) center. As is the case with other unprecedented emergencies, an effective, rapid response was necessary, and the C4 continued to evolve once operational. Those of us involved in this process have described the experience as akin to “building a plane while flying it,” and this unique aspect of the project informed future design decisions.

CIPs were initially recruited through the state’s Society of Critical Care Medicine Chapter as well as messaging via critical care leaders within each of the state’s main healthcare systems. CIPs are required to be actively licensed in Maryland with a minimum of 800 hours of dedicated annual critical care experience. Initially, clinical coordinators consisted of MIEMSS regional administrative staff, all of whom were experienced paramedics. A medical director was appointed to coordinate and synchronize C4 operations, with additional oversight provided by the Executive Director of MIEMSS and the System Chief of Critical Care for the University of Maryland Medical System. During its’ first full month of operation, the C4 received 225 requests for critical care services and transfer assistance. MIEMSS began augmenting its coordinator staff with contractual paramedics to cover the ever-increasing call volume beginning in January of 2021. The decision to continue to utilize paramedics to fulfil the clinical coordinator role was a novel concept in hospital bed coordination, as nurses have traditionally fulfilled this role in other centralized bed coordination centers.

The CIP and clinical coordinator maintain situational awareness of critical care beds, ventilators, and additional critical care resource availability throughout the state during their shifts in preparation for requests. Updated bed status information from the Chesapeake Regional Information System for our Patients (CRISP™) and real-time MIEMSS hospital alert status data is collected to a MIEMSS-designed Patient Resource Database (Figure 3). Coordinators and CIPs also participate in daily hospital system bed status meetings when feasible to supplement CRISP data. Pertinent information relating to beds and resources, especially during periods of scarce availability, are passed along to from shift to shift.

When a call is received by the C4, a complex but succinct process is followed (Figure 4). At call onset, the clinical coordinator collects basic information from the caller including patient demographics and requested services, then connects the referring clinician to the CIP. The CIP listens to the case presentation, determines the acuity of the patient, and provides medical direction to facilitate continuity of care from ED to ICU following standard care processes in addition to disseminating novel information and treatment protocols from the latest transitional research. The CIP and coordinator determine the most appropriate transfer destination for the patient, based upon information gleaned from the consult. Factors involved in this decision included the current statewide hospital bed situation, medical need for specialized or advanced critical care, patient prognosis, distance from potential accepting facilities, stability of patient for transfer, and ability of the referring facility to manage the patient in house. If transfer is determined to be the best disposition for the patient, the coordinator begins searching for a receiving hospital. Using an organized list of contact information and current bed status information, the clinical coordinator identifies potential receiving facilities to search first in order to maximizing results in shorter time spans. The process is truly a team effort utilizing the knowledge and experience of both the CIP and clinical coordinator.

Figure 3. Maryland Hospital Capacity Resource Database

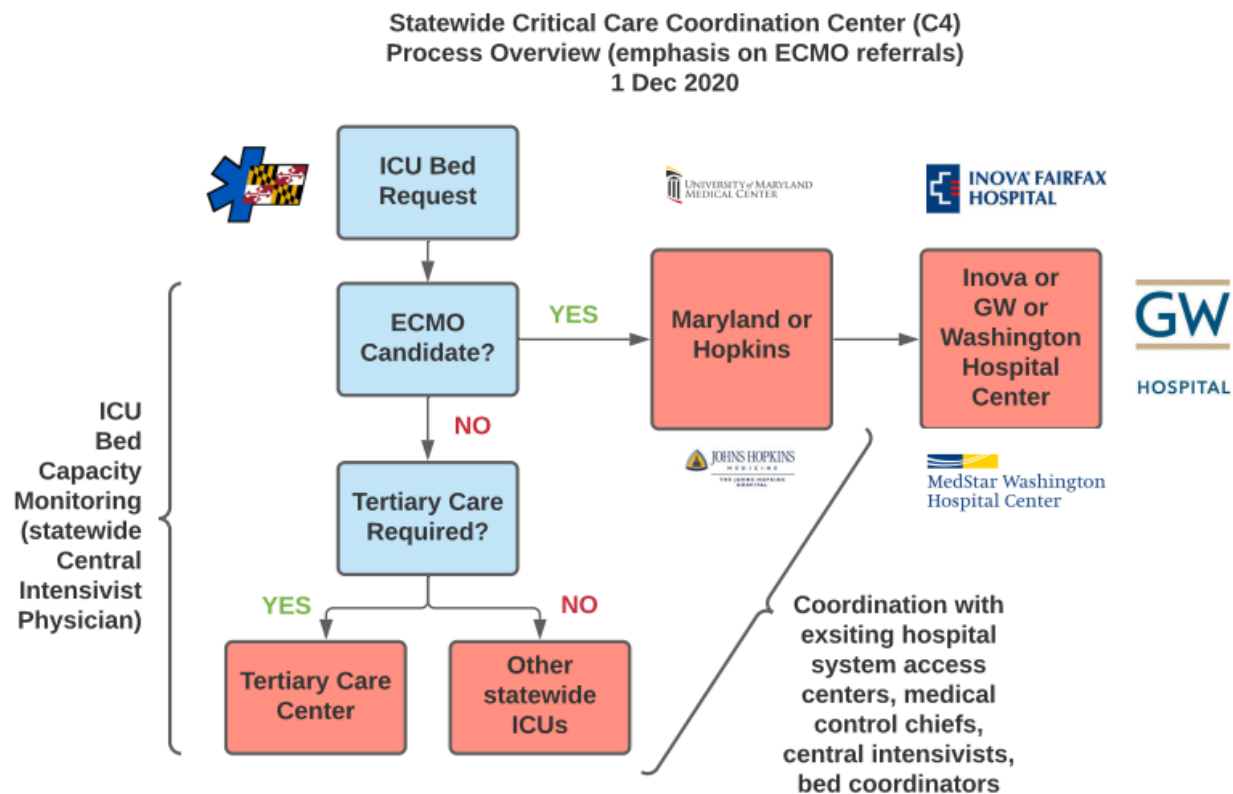
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| | Region | Facility Name | ID | Designations | A ICU Level | P ICU Level | A ICU Available | A Acute Care Available | P ICU Available | P Acute Care Available | ECMO | ECMO Adult | ECMO Photo/Neonate | Proning | Pulmonary Vasodilators | CBRT | CCM |
|----|---------------|---|-------------|--------------------------------|-------------|-------------|-----------------|------------------------|-----------------|------------------------|------|------------|--------------------|---------|------------------------|------|-----|
| 16 | Region III | Mercy Medical Center | 21 10:59 AM | P Stroke, Perinatal | 2 | | 12 | 55 | 5 | 0 | N | 0 | 0 | Y | Y | Y | |
| 17 | Region III | Midtown (UM) | 21 11:27 AM | P Stroke | 2 | | 0 | 2 | 0 | 0 | N | 0 | 0 | Y | Y | Y | |
| 18 | Region III | Northwest Hospital | 21 11:14 AM | P Stroke | 3 | | 1 | 5 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 19 | Region III | Sinai Hospital of Baltimore | 21 10:36 PM | CIC, P Stroke, Adult Trauma | 2 | | 1 | 4 | 0 | 1 | N | 0 | 0 | Y | N | N | |
| 20 | Region III | St. Agnes Hospital | 21 9:57 AM | CIC, Primary Stroke, Perinatal | 3 | | 2 | 1 | 0 | 4 | N | 0 | 0 | Y | N | N | |
| 21 | Region III | St. Joseph's (UM) | 21 3:14 PM | CIC, P Stroke, Perinatal | 2 | | 0 | 2 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 22 | Region III | Union Memorial Hospital (MedStar) | 21 11:09 AM | CIC, Hand/Upper Extremity | 3 | | 2 | 2 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 23 | Region III | University of Maryland Medical Center | 21 12:09 PM | Adult Trauma, Hyperbaric, h | 1 | | 0 | 15 | 2 | 0 | MMV | 0 | 0 | Y | Y | Y | |
| 24 | Region III | Upper Chesapeake Medical Center (UMJCH) | 21 10:33 AM | CIC, P Stroke | 2 | | 0 | 4 | 0 | 0 | N | 0 | 0 | Y | Y | N | |
| 25 | Region IV | Atlanta General Hospital | 21 10:24 AM | P Stroke | 3 | | 2 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 26 | Region IV | Chestnut (UMSBH) | 21 9:22 AM | | 3 | | 0 | 2 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 27 | Region IV | Easton (UMSBH) | 21 1:14 PM | CIC, P Stroke | 3 | | 1 | 1 | 0 | 2 | N | 0 | 0 | Y | N | N | |
| 28 | Region IV | Peninsula Regional Medical Center | 21 9:21 AM | CIC, P Stroke, Adult Trauma | 3 | | 0 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 29 | Region IV | Union Hospital of Cecil County | 21 11:05 AM | P Stroke | 3 | | 4 | 7 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 30 | Region V | Calvert Memorial Hospital | 21 10:10 AM | P Stroke | 3 | | 0 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 31 | Region V | Charles Regional (UM) | 21 11:14 AM | | 3 | | 4 | 0 | 0 | 4 | N | 0 | 0 | Y | N | N | |
| 32 | Region V | Doctors Community Hospital | 21 9:32 AM | P Stroke | 3 | | 0 | 2 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 33 | Region V | Fort Washington Hospital | 21 10:05 AM | | 3 | | 0 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 34 | Region V | Ft. Washington ACS | 21 10:05 AM | | 3 | | 1 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 35 | Region V | Holy Cross Germantown | 21 9:35 AM | Primary Stroke | 3 | | 0 | 2 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 36 | Region V | Holy Cross Hospital | 21 10:31 AM | CIC, P Stroke, Perinatal | 2 | | 0 | 0 | 0 | 4 | N | 0 | 0 | Y | N | N | |
| 37 | Region V | Laurel Regional Medical Center | 21 9:59 AM | | 2 | | 13 | 22 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 38 | Region V | Montgomery Medical Center (MedStar) | 21 9:58 AM | | 3 | | 1 | 0 | 0 | 1 | N | 0 | 0 | Y | N | N | |
| 39 | Region V | Prince George's Hospital Center | 21 1:06 PM | CIC, Adult Trauma, Perinatal | 2 | | 0 | 1 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 40 | Region V | Shady Grove Adventist Hospital | 21 10:27 AM | CIC, Primary Stroke, Perinatal | 3 | | 1 | 10 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 41 | Region V | Southern Maryland Hospital (MedStar) | 21 11:14 PM | CIC, Primary Stroke | 3 | | 0 | 11 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 42 | Region V | St. Mary's Hospital | 21 11:14 PM | P Stroke | 3 | | 0 | 15 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 43 | Region V | Suburban Hospital | 21 11:02 AM | CIC, P Stroke, Adult Trauma | 3 | | 0 | 11 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 44 | Region V | Walter Reed NMIC | 21 10:42 AM | | 1 | | 5 | 22 | 4 | 1 | MMV | 0 | 0 | Y | N | N | |
| 45 | Region V | Washington Adventist ACS | 21 1:06 PM | | 3 | | 0 | 24 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 46 | Region V | White Oak Medical Center | 21 11:14 PM | | 3 | | 7 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 47 | Washington DC | Children's National Medical Center | 21 9:29 AM | | | | 0 | 0 | 0 | 0 | N | 0 | 0 | Y | N | N | |
| 48 | | | | | | | | | | | | | | | | | |
| 49 | | | 21 1:19 PM | Total Adult ICU Region I | 3 | | | | | | | | | | | | |
| 50 | | | 21 2:10 PM | Total Adult ICU Region II | 8 | | | | | | | | | | | | |
| 51 | | | 21 3:14 PM | Total Adult ICU Region III | 62 | | | | | | | | | | | | |
| 52 | | | 21 11:09 AM | Total Adult ICU Region IV | 7 | | | | | | | | | | | | |
| 53 | | | 21 1:14 PM | Total Adult ICU Region V | 33 | | | | | | | | | | | | |
| 54 | | | 21 3:14 PM | Total Adult ICU Statewide | 145 | | | | | | | | | | | | |

While the clinical coordinator performs the administrative duties associated with contacting potential receiving hospitals until a suitable transfer destination is identified, the CIP remains available to liaise in place of the referring physician, allowing them to continue caring for their patients. Once the coordinator finds a potential match they connect the sending clinician with the receiving facility for case presentation and final acceptance. Throughout the process, communication is maintained with requesting facilities to keep them apprised of the status of the transfer. When bed resources were especially scarce, the CIP maintained contact with referring clinicians at regular intervals to check on patient status and make continued recommendations for treatment.

As each request is unique and determined by the current acute care bed situation, the C4 highlights the benefits of a team approach utilizing the clinical knowledge and experience of a board certified critical care physician and the innovative problem solving and critical thinking abilities of a paramedic coordinator. The team's pooled expertise determines the best plan for clinical management of each patient while simultaneously considering the clinical capabilities of the facilities involved, the availability of critical care and acute beds and their distribution across the state, unique geography, weather, and transportation constraints, as well as the probability of a positive prognostic outcome for the patient. This novel approach to combined patient and resource management stands as an example of how a public safety based organization can help mitigate healthcare disparities during hospital surges and staff shortages.

Figure 4. Maryland C4 critical care transfer process model



Evolution of Operations

As several peaks and valleys have been experienced throughout the pandemic and new challenges arose, changes and improvements were made to C4 operations and staffing. As relationships were established with ICUs throughout the state, new CIPs were recruited to the program to increase the institutional representation and diversity of the physicians. Two lead coordinator positions were created to establish quality assurance and quality improvement strategies and act as a second coordinator during busier hours.

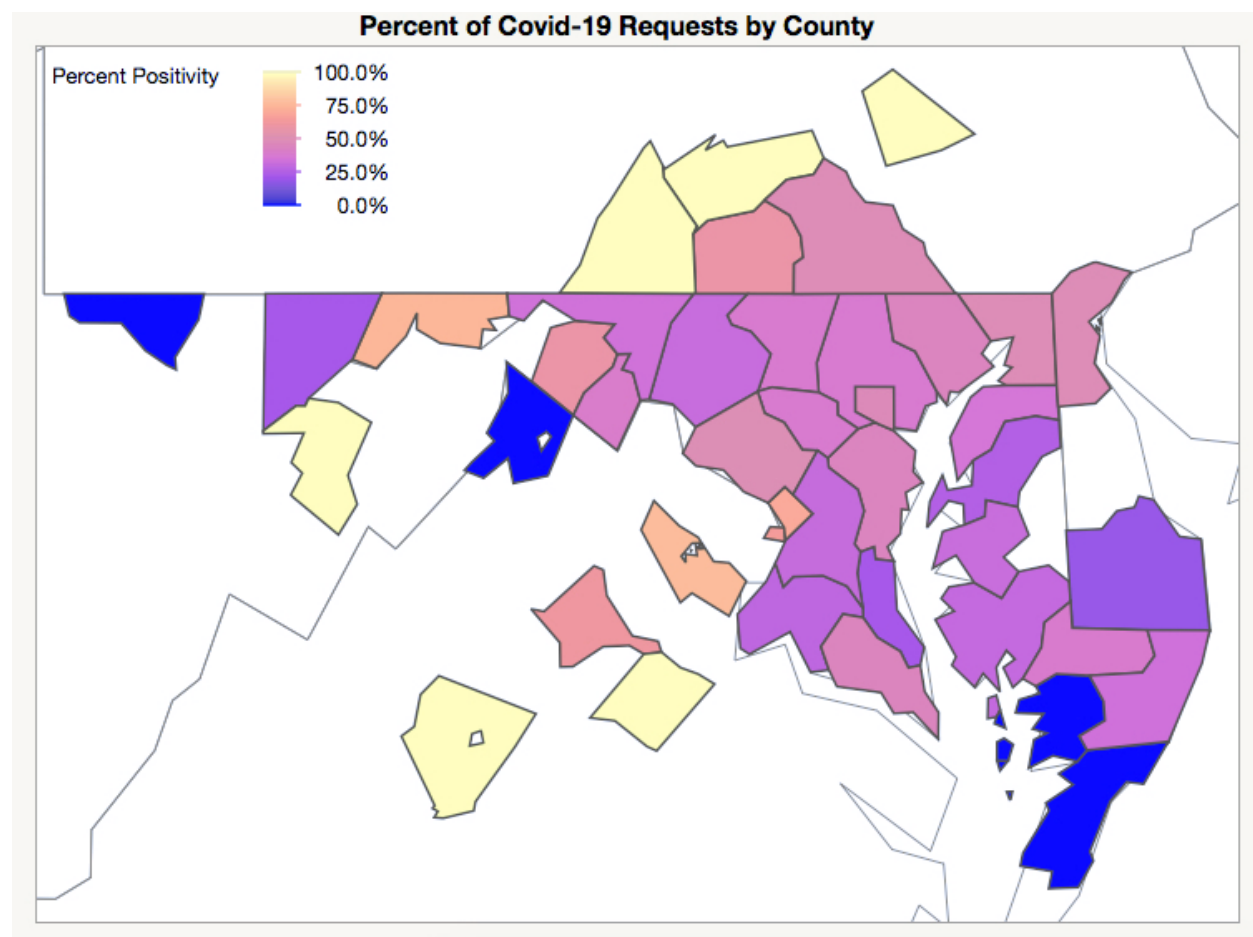
Beginning on October 1, 2021, the C4 began accepting consults for pediatric critical care and transfer resources, staffing the center full time with two clinical coordinators, a CIP for adults and a Central Access Pediatric Physician (CAPP) for pediatric requests. These two teams work synchronously to manage a wide variety of cases and critical care needs. At the time of this writing, the C4 maintains a staff of 80 contracted coordinators & critical care physicians.

Program Results⁹

The C4 received 2,634 service requests between its inception on November 30th, 2020 through March 31, 2022. Excluded from these are 143 requests (5.4% of total) for lower-level services, which are out of the scope of critical care handled by the C4. Remaining are 2,491 requests for critical care services and transfers. Of these, 1,592 (63.9%) resulted in successful transfers facilitated by our C4 team and 874 (35.1%) were effectively managed with clinical guidance from the CIP within requesting facilities. The remaining requests (26, 1.0%) include cancellations and other dispositions.

Out of 2,491 critical care requests, 953 (37.6%) involved patients confirmed to test positive for COVID-19 or were persons under investigation (PUI) for COVID-19. Figure 5 shows the percentage of COVID-19 positive or PUI patients geographically compared to total requests by originating county. Over half of COVID-19 positive or PUI patients (538, 58.2%) were successfully transferred. Approximately 62% of all transfer requests reported a negative COVID-19 test result.

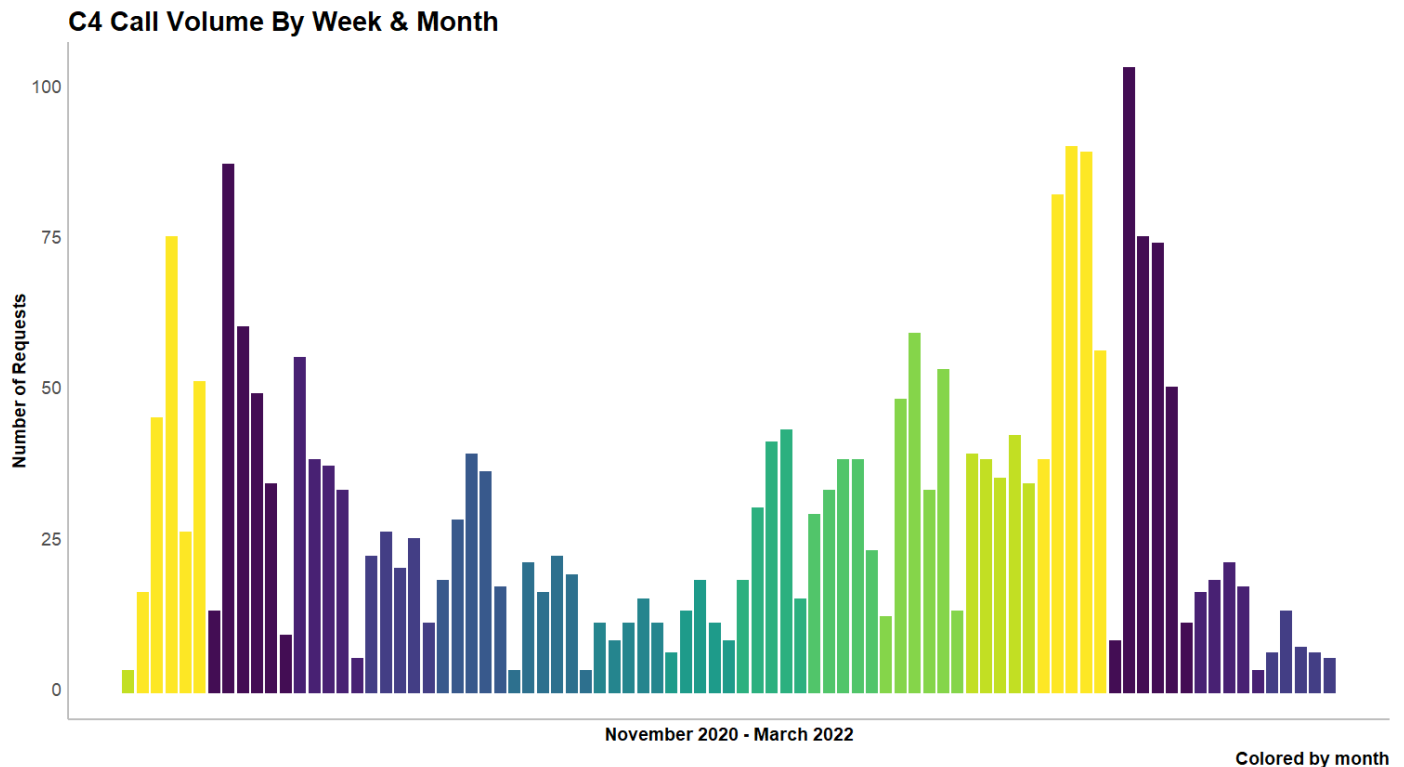
Figure 5. C4 COVID-19 transfer requests¹⁰



⁹ Statistical analysis performed in JMP® Pro for MacOS, Version 15.2.1. SAS Institute, Inc. Cary, NC, 1989-2021.

¹⁰ Figure created using JMP® Pro for MacOS, Version 15.2.1. SAS Institute, Inc. Cary, NC, 1989-2021

Figure 6. Number of C4 requests by week & month¹¹



Of total requests, 175 (7.0%) involved Extra Corporeal Membrane Oxygenation (ECMO) services, of which 31.4% (55) were successfully transferred, and 57.1% (100) were managed in the requesting facility with medical direction from the CIP.

In many cases transfer requests were initiated and completed between hospitals located in the same or neighboring region or jurisdiction. This was a direct result of one of the primary goals of the C4; to locate the closest appropriate bed for the patient. For example, in Region III there were a total of 454 patients transferred, of which 65% were received by hospitals in Region III, 15% were received by hospitals in neighboring Region V, and 12% were transferred out-of-state (7.5% to DC, 4.8% to Northern VA, Figure 7).

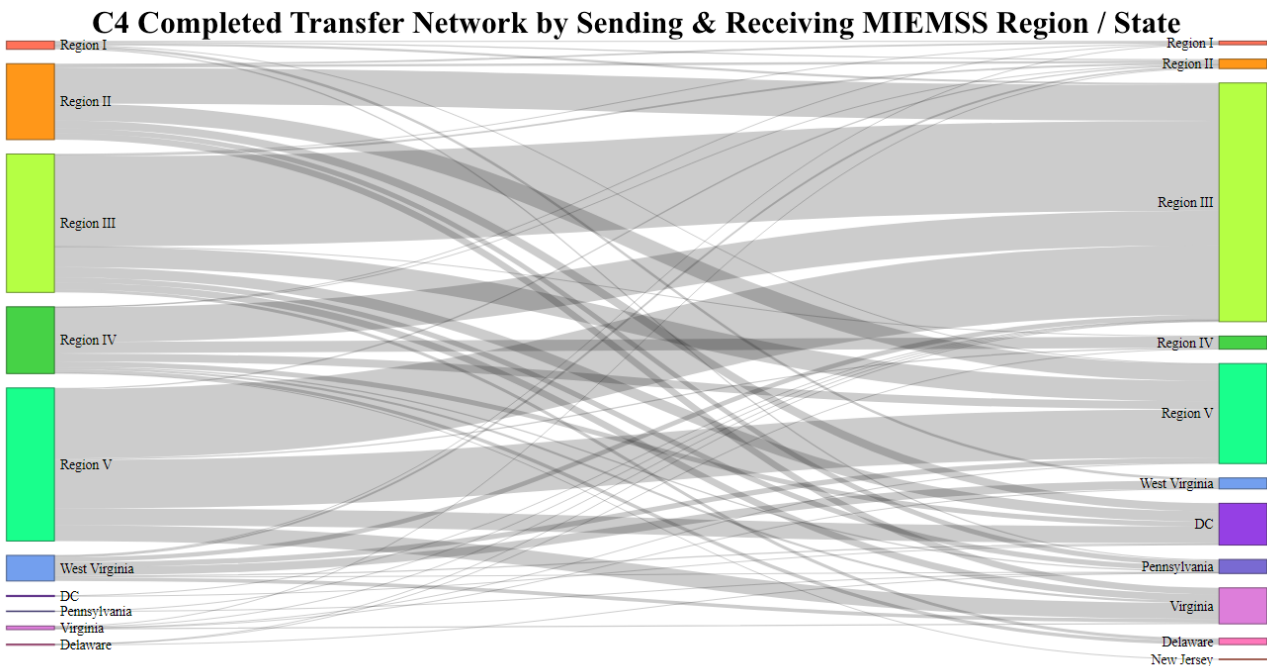
The average transfer distance between sending and receiving hospitals was 37.1 miles, and over 75% of transfer distances are under 50 miles. When a closer option was unavailable to a patient in need, the C4 facilitated transfers of much greater distances. The C4 facilitated 73 transfers (4.5%) to locations greater than 90 miles away from patient origin, recording a maximum distance of 193 miles.

The largest proportion of requests originated in Region III (787, 31.6%) and Region V (750, 30.1%), coinciding with Maryland's largest metropolitan areas. Region II initiated 383 requests (15.4%), Region IV initiated 310 requests (12.5%), and Region I initiated the fewest number of transfer requests (39, 1.6%). The largest volume of out-of-state requests came from West Virginia (137, 5.5%), and additional out-of-state requests originated from Virginia (43), Pennsylvania (18), the District of Columbia (15), and

¹¹ Figures 6 – 8 created using R Studio for MacOS, Version 1.3.1093. RStudio: Integrated Development for R. Studio, Inc., 2009-2020, Boston, MA URL <http://www.rstudio.com/>

Delaware (7). The C4 received 2 requests from Maryland residents vacationing in Caribbean nations for repatriation back to hospitals in their home state.

Figure 7. Completed transfer distribution network, by state and MIEMSS region



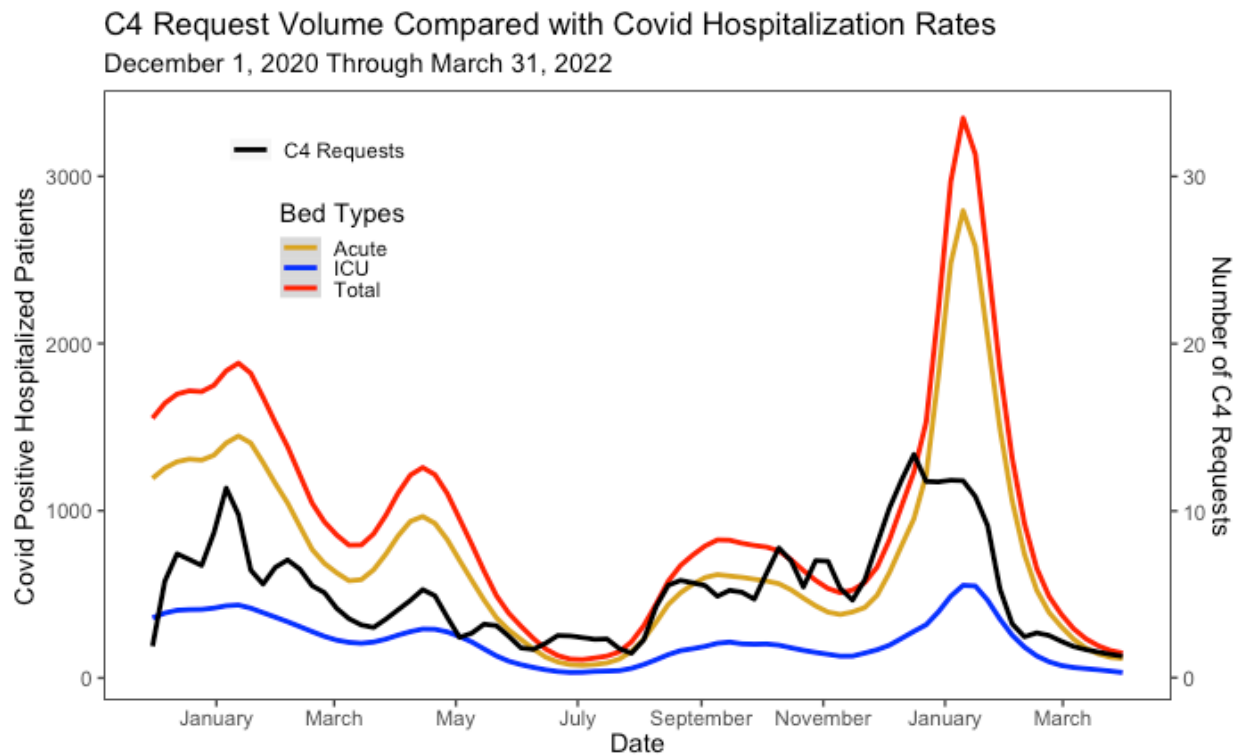
The majority of transfers went to Region III (784, 50.3%), followed by Region V (328, 21.1%), the District of Columbia (137, 8.8%) and Virginia (118, 7.6%), coinciding with higher distributions of hospitals in these areas. The remaining transfer requests were received by hospitals in Maryland's Regions IV, I and II, as well as hospitals in Delaware, Pennsylvania, West Virginia and New Jersey. With the exception of the freestanding emergency facilities (without admitting capabilities), every hospital in Maryland has been both a requesting and receiving hospital through the C4 program, demonstrating the cooperative statewide and interstate efforts of both hospitals and clinicians during this unprecedented time.

After expanding to include pediatric services in October of 2021, 47 requests were received for pediatric patients, 43 of whom (91.5%) were successfully transferred.

C4 operations began on November 30, 2020 and increased dramatically throughout December of 2020 and January of 2021 before a gradual reduction through the summer months of 2021. Another, larger peak was observed in December of 2021 and January of 2022, coinciding with the largest increase of COVID-19 hospitalized cases in Maryland since the initial peak of cases in May of 2020. The number of transfer requests received by the call center on a daily and weekly basis fluctuated with COVID-19 waves and lulls (Figures 6 & 8).

December of 2021 was the busiest month for the C4, fielding 350 (14.1%) calls. January of 2022 was the second busiest month (315, 12.6%), followed by January of 2021 (246, 9.9%) and October of 2021 (212, 11.4%).

Figure 8. C4 critical care transfers and COVID-19 hospitalization rates over time



Summary & Future Implications

This project has been ever evolving since its inception, and its success would not have been possible without the dedication of MIEMSS staff, contractual coordinators and physicians.

We are working on more rigorous methodological approaches that can further our understanding of the benefits and impacts of C4 on our patient population. Anecdotally, we present some of the most significant benefits observed by our coordinators, physicians and MIEMSS executive staff members.

A single ECMO consult can take up to 30 minutes or more of an attending physician's time, and during peak waves of COVID-19, a consult might be repeated to multiple tertiary care receiving centers until suitable placement is found. Our CIPs utilized their knowledge of the criteria, guidelines, and efficacy of this scarce resource to make treatment and suitability recommendations to referring physicians and present these cases to tertiary care centers. C4 involvement allows treating physicians to maximize their efforts advocating for patients without repetitive calls to multiple institutions, saving time and allowing them to better care for their patients.

Transfer requests to the C4 closely followed COVID-19 hospitalization rates for both acute care and ICU beds (Figure 8). The C4 effectively facilitated patient load balancing across Maryland hospitals more equitably, enhancing quality of care and patient outcomes. The center also improved the quality of Emergency Department care when ICU beds were at limited capacities through clinical guidance, preventing unnecessary transfers, and allowing many patients to recover closer to their home and family.

By establishing a comprehensive list of hospital specialties and critical care abilities, C4 coordinators and CIPs were able to quickly locate potential receiving facilities for patients who would otherwise be waiting for placement in a tertiary care hospital. By suggesting and facilitating alternatives to the long-ingrained transfer networks established pre-surge, the C4 helped move patients more quickly to ICU level care, decreasing ED boarding time and improving outcomes for those requiring specialty treatments and procedures.

During times of extremely limited statewide ICU capacity, emergency department physicians expressed gratitude for the medical direction provided by the C4 physicians. While the coordinators worked to find placement for patients, CIPs and CAPPs provided treatment options, suggested best practices from their home ICUs and academic centers, and shared alternatives to admission to include ordering diagnostic studies or medication courses that would further treatment while awaiting ICU placement. Some patients who were unable to be immediately transferred were instead able to be downgraded to a lower than ICU level of care through the combined efforts of the treating clinician and CIP, both reducing the strain on the statewide critical care system and benefiting the patients.

Through this evidence and the dedication of our staff, we consider future innovations and are actively planning on expanding our services to include telemedicine in addition to current telephone consultation. A significant proportion of C4 requests are for advanced tests or monitoring – modalities that could potentially be performed with telemedicine. The ability of the CIP to more definitively determine needed level of care during patient intake would ensure limited specialty beds at tertiary facilities are utilized effectively and further reduce unnecessary patient transfers. Another long term system goal is the continuing education of emergency room physicians and prehospital clinicians. By tracking trends in the types of calls received and their dispositions, CIPs can identify critical information that requires widespread dissemination to further reduce healthcare disparities for special populations in areas with limited access to tertiary care. Through education, destination steering for prehospital clinicians and emergency room management of specialty care patients, especially pediatrics, care can be improved resulting in better outcomes and greater efficiency of the healthcare system.

As we continue to move forward with this project “from pandemic to permanence”, we commit to continue Maryland’s history of innovative medicine and partnerships by providing additional services to further reduce the access gap. The C4 has experienced significant growth, as evidenced by the addition of a pediatric intensive care consultant, addition of a back-up CIP during peak call periods, and doubling of the coordinator staff. These process improvements have expanded the services provided by C4 to include patients of all ages. C4 physicians and coordinators are researching the logistics of telemetry-based specialty care consultation and telemedicine to more quickly diagnose specific conditions, improve outcomes, alleviate strain on tertiary and quaternary institutions and reduce the number of unnecessary patient transfers. The success and continued utilization of the C4 over a year after its inception have given emergency and critical care clinicians an indispensable support system during an unprecedented public health emergency. The Critical Care Coordination Center has provided opportunities for Maryland to continue its mission of ensuring that *“the right patient gets to the right destination at the right time”*.

The final section of this report contains a few of the individual case success stories documenting our efforts throughout C4 operations.

Case Studies

A woman with Sjogren’s disease and pulmonary hypertension presented to a community emergency department with severe dyspnea. The patient was found to be infected with COVID-19. The C4 provided

recommendations regarding steroids and non-invasive medical therapy prior to coordinating transfer to a tertiary care ICU 54 miles away. Intubation was avoided and the patient experienced a full recovery.

A male Department of Corrections detainee presented to the ED at a small community hospital in western Maryland with COVID pneumonia. The patient was intubated and medical direction was provided by the C4. Transfer was coordinated via the C4 to move the patient to an ICU located 172 miles away. The patient experienced a full recovery.

A young man presented to a community emergency department in southern Maryland with severe carbon monoxide poisoning. Two other people were found deceased at the scene. The patient was intubated and rapidly transferred to the R Adams Cowley Shock Trauma Center for emergent hyperbaric oxygen therapy. The patient experienced a full recovery and survived neurologically intact.

A woman was admitted to an ED in Baltimore with suspected olanzapine intoxication. Medical direction was provided through a coordinated effort between the Maryland Poison Center and the C4 Central Intensivist to assist with management of this unique patient. The C4 coordinator was able to locate and secure a bed in an ICU in Baltimore and transferred this patient on a day when ICU capacities were extremely limited statewide.

A woman presented with weakness to a community hospital in central Maryland and an MRI suggested a possible epidural abscess. An urgent request was received by the C4 seeking emergency neurosurgical consultation. The C4 facilitated a call to a Johns Hopkins neurosurgeon who was able to assist with a review of the images, and confirmed that surgery was not indicated. The patient ultimately did not require an urgent transfer and was managed successfully with clinical guidance provided by telemedicine at the community hospital.

An elderly man presented to the an ED on the eastern shore after sustaining a fall. A subdural hematoma was discovered and urgent neurosurgery sought. The family was informed that no hospital within the region has neurosurgical capabilities. One family member, a nationally registered paramedic, was familiar with the C4 and asked the ED staff to contact us. The C4 successfully coordinated a transfer to an ICU in Delaware where the patient had a craniotomy.

A patient in a community hospital in central Maryland was intubated in the ED having been diagnosed with COVID pneumonia. No ICU beds were available in the region or in the state on that day. The C4 protocol includes screening for government facilities, and the C4 discovered the patient was a veteran. Transfer was successfully coordinated to the ICU at the Walter Reed National Military Medical Center.

A woman presented to the a freestanding ED with diabetic ketoacidosis, a condition which can be effectively reversed given time, patience, and appropriate treatment. ICU beds were incredibly limited throughout the state. The patient was followed throughout the shift and managed in place with clinical guidance provided by the C4 until she improved enough to be downgraded from ICU status and eventually discharged home.

A man with stage IV lung cancer was admitted to an ED in the eastern shore after ROSC following a cardiac arrest. A request for ICU transfer was made through the C4, but no ICU beds were available. After an extensive review of the case, the C4 assisted the staff with the decision to transition the patient to comfort care; a palliative medicine consultant was contacted by the CIP and connected to the providers at the hospital to assist the clinicians and family through the difficult decision-making process.

A man was admitted with COVID pneumonia to a community ICU. The patient was persistently hypoxemic and the ICU staff contacted C4 for medical direction ECMO referral. The patient was

screened but declined for ECMO due to capacity at all state ECMO centers. The CIP remained on the line for over an hour helping the ICU team adjust the ventilator to improve oxygenation of the patient. Ultimately, ECMO was not required.

A man with Cerebral Palsy was admitted to a community ED in central Maryland on Christmas Day after experiencing aspiration. EMS nasally intubated the patient in the field. The physician requested ICU placement through C4 due to capacity limitations at their facility. The C4 team with their knowledge of the state hospital system, and recognizing the patient's anatomy and physiology, secured a bed for the 22-year-old male in a tertiary ICU in Baltimore.

A young man presented to a freestanding ED in diabetic ketoacidosis. No ICU beds were available throughout the state, and the patient's laboratory values were critical enough that hospitalization would be necessary. While researching the case through the electronic health record, the C4 team saw that the patient had been followed as a juvenile diabetic at Children's National Medical Center and had only recently become an adult. The C4 contacted Children's who accepted this patient for ICU level care.

A young and otherwise healthy woman presented to the ED at a community hospital outside of Baltimore the morning after a fall complaining of a headache. She was found to have a small subdural hematoma and a request was made through the C4 for traumatic neurology services. The CIP provided clinical guidance that included a brief observation period, a follow-up CT scan, and seizure prophylaxis that allowed this patient to be discharged from the ED for outpatient follow-up. Without C4 involvement, this patient may have incurred ambulance transportation to a trauma center further from home and additional medical testing while simultaneously depleting the state's limited trauma ICU capacity.