Preventing Hospitalization Through a No-Frills Remote Monitoring Program

Mackenzie Health

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Executive Summary

Mackenzie Health, an innovative, HIMSS Stage 7 hospital, operating two full-service hospitals including Mackenzie Richmond Hill Hospital and Cortellucci Vaughan Hospital and a network of community-based programs and services we serve a population of more than half a million people across western York Region which is in the Greater Toronto Area in Ontario, Canada. Both hospitals offer a range of core services with specialized programs at each. Between the two hospitals, we see over 200,000 Emergency Visits and 48,999 admissions annually. The organization employs 5200 staff and has 550 physicians credentialed. The hospital is committed to its corporate digital strategy focusing on opportunities to improve clinical patient outcomes through technology. Building on our previous HIMSS Davies recognized work in chronic obstructive lung disease (COPD), we were in the planning stages for a remote COPD clinic utilizing a comprehensive virtual care delivery model. When the COVID-19 pandemic hit, there was an urgent need to pivot this virtual clinic to manage the significant and rapidly growing COVID-19 population.

During the first wave of COVID-19 in Ontario, Canada, there was an unprecedented hospitalization rate of ED patients presenting with lower respiratory tract infection due to COVID-19 pneumonia. To reduce bed pressures, Mackenzie Health implemented a virtual

Acute Respiratory Clinic (ARC) using an inexpensive, “no-frills” remote-monitoring approach that utilized home monitoring and reporting of oxygen saturation, heart rate (HR), and temperature in conjunction with virtual visits and discrete collection of symptom data. Automated triage algorithms and threshold notifications were used to initiate treatment of patients at home with oxygen and glucocorticoid therapy to avoid hospitalization of moderately at risk COVID-19 positive patients. The ARC remote monitoring program ran as a pilot July 1, 2020, then officially from September 2020 to June 2021, enrolled 6065 COVID-19 patients, remotely monitored 1360 patients, conducted 10,236 virtual visits, prevented 1065 hospital admissions, trended towards reduced in-patient mortality, and saved the hospital system $4.3 – 7.8 million CAD. The project also demonstrated the feasibility, clinical, and operational value of a “no-frills” approach to remote monitoring that can be operated on a limited budget and without significant investment in HIT interoperability.

Define the Clinical Problem and Pre-Implementation Performance

In early 2020 prior to COVID-19, Mackenzie Health planned to provide virtual care including monitoring of oxygen saturation on COPD patients. Virtual care would enable this cohort of patients to continue treatment in the comfort of their own homes during an exacerbation period. While planning was underway in March 2020, a pivot occurred at the onset of Ontario COVID-19 Wave 1 (Mar 2020 – May 2020). Mackenzie Health's bed capacity was already stretched to 115-120% occupancy due to population pressure alone, with a new hospital site still 10 months away. During COVID-19 Wave 1, there was an unprecedented hospitalization rate of ED patients presenting with lower respiratory tract infection due to COVID-19 pneumonia, with admission rates of up to 74% of patients by age group (Figure 1), approximately three times higher than pre-pandemic rates for lower respiratory tract infection. The additional volume of admissions put extra strain on hospital capacity and necessitated the use of further non-conventional bed spaces and a rethinking of the traditional pre-pandemic care delivery model. By September 2021 there was evidence of a new COVID-19 wave building, and it became clear that a diversion strategy was needed to minimize COVID-19 admissions and help prevent the hospital's ED and inpatient capacity from being overwhelmed.

The World Health Organization (WHO) Ordinal Scale for Clinical Improvement (OSCI) was used to categorize patients at admission. Hospitalization rate was calculated as $\frac{\textit{Primary COVID patients admitted with OSCI}\geq 3}{\textit{All admitted and non-admitted primary COVID patients}}$.

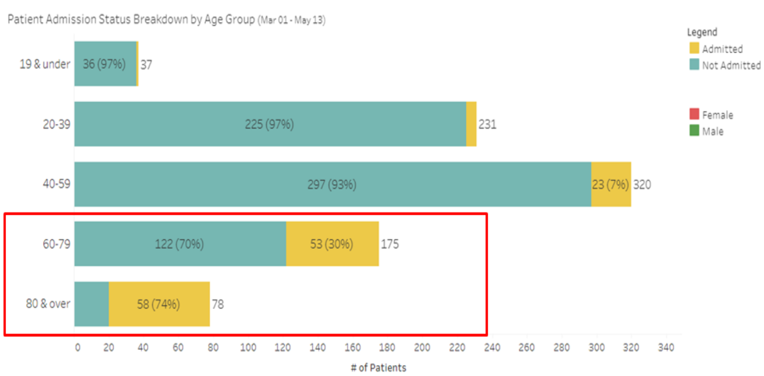

Figure 1. Wave 1 COVID-19 pneumonia hospitalization rate by

Patient State	Descriptor	Score
Uninfected	No clinical or virological evidence of infection	0
Ambulatory	No limitation of activities	1
	Limitation of activities	2
Non-ambulatory/Hospitalized Mild disease	Severe functional limitation due to infection OR hospitalized, no oxygen therapy	3
	Severe functional limitation due to infection OR hospitalized, oxygen by mask or nasal prongs	4
Hospitalized Severe Disease	Non-invasive ventilation or high-flow oxygen	5
	Intubation and mechanical ventilation	6
	Ventilation + additional organ support – pressors, RRT, ECMO	7

Figure 4. Modified WHO OSCI scale for outpatients.

The organization's initial goal was to reduce the total number of COVID-19 hospitalizations by utilizing virtual care technology to manage moderate risk patients (modified OSCI 3-4) in their homes rather than in the hospital. The target population was selected based on the markedly higher observed admission rates for patients age > 60. We targeted all patients age > 60 who tested positive for COVID-19 by PCR at our ambulatory COVID-19 Assessment Centre, Urgent Care Centre, or Emergency Department and screened these patients for enrollment in a virtual care program. We used a modified version of the WHO

OSCI score to screen patients for enrollment prior to hospital admission (Figure 2). Patients with modified OSCI 2-4 were targeted for enrollment.

The initial goal was to enroll five hundred moderate risk patients and prevent fifty hospital admissions by managing nominal OSCI 3-4 patients outside of hospital using traditionally in-hospital COVID-19 therapies. Enrollment target was increased to 1500 before the start of the project period at the request of Ontario Health. The target population was also adjusted in the Spring of 2021 when younger cohorts with the virus were being admitted. The age was dropped to patients > 40. Due to the overwhelming numbers the organization had to add additional resources including twenty-five physicians and four nurses to ensure people were properly cared for.

Design and Implementation Model Practices and Governance

In 2019, Mackenzie Health was engaged in a needs assessment for clinical remote monitoring for our COPD patient population as part of a Quality Based Program initiative and were in discussion with Ontario Health for funding for a pilot project. We had planned to deploy an end-to-end solution for in-home remote monitoring including a secure interoperability platform for data acquisition, hospital-deployed tablet device, and medical grade telemetry-capable medical devices.

Utilizing the initial work done for COPD remote monitoring, we had planned for the full rollout of a connected virtual care platform for monitoring of ambulatory moderate risk COVID-19 patients. However, with rapidly rising case rates, budgetary constraints, and operational resources fully committed to supporting the immediate needs of a large burden of COVID-19 patients as well as the commissioning of a new hospital site, there was uniform agreement between the ICAT department and hospital leadership that a less technology focused, more data-driven workflow would be essential.

Executive approval was obtained for the establishment of a virtual Acute Respiratory Clinic (ARC). Project governance model and key stakeholders are shown in Figure 3. The remote monitoring initiative was physician led and the Department of Medicine and the Division of Respirology as physician subject matter amongst the planned end-users of the ARC workflow.

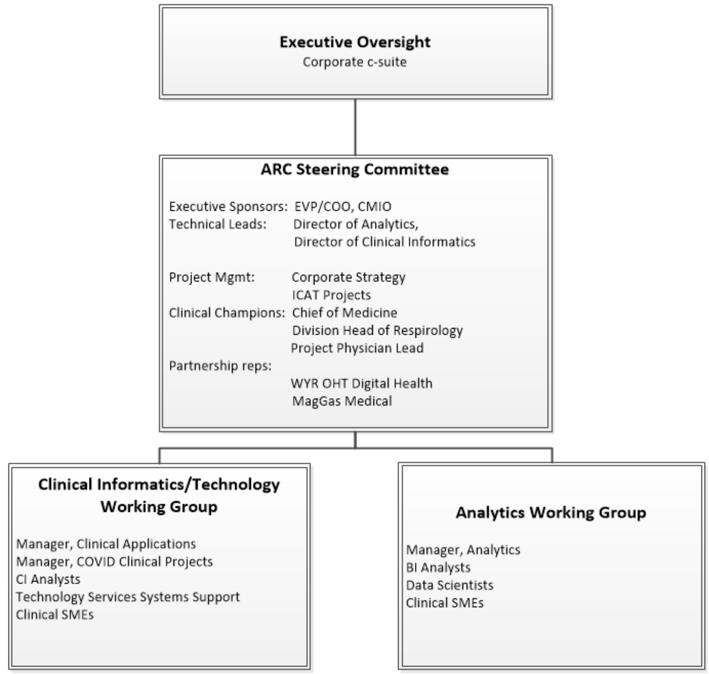

Figure 7. Project governance model

Early in the ARC workflow design process it was clear that external partnerships would be required to provide additional support in the community, and we engaged our Western York Region Ontario Health Team (community care partnership) as well as MagGas (home oxygen delivery vendor). York Regional Public Health participated in a review of the project proposal but did not participate in the final workflow design as they were extremely overwhelmed with surveillance activities in the region. They benefited from the results of the project as the patients that were participating no longer required surveillance from them and they could concentrate on others in need. Additionally, clusters of infection that were determined by the program provided much needed information to Public Health to target individuals not yet infected but having been in close contact with those that were sick. An example of this was local warehouse distribution centres. Our data showed that the majority of those infected in the catchment area came from construction or industrial origins As a result of the ARC program this cluster of infections was identified, and Public Health provided diversion/closure/surveillance guidance to all that were affected but not yet showing symptoms.

Key requirements identified during the design process were: 1) rapid referral process with simple triage criteria, 2) 24/7 support for patients, 3) clear escalation pathway for clinical decompensation, 4) audio and video teleconferencing support, 5) near real-time collection of key physiological parameters (e.g. SpO2, HR), 6) longitudinal collection, analysis, trending of objective and subjective patient data, 7) use of automation rules/technology to identify at risk patient population – so-called “happy hypoxics” (clinically asymptomatic but physiologically deranged).
It was determined quite early in the workflow development that there was not sufficient time or resources to implement an interoperability platform for data collection and a decision was made to utilize patient collected data via the hospital’s secure patient portal supplemented by physician collected data from the actual virtual visits.

Training of clinical end-users was performed by a clinical (physician) trainer in collaboration with an ICAT trainer using a "train-the-trainer" model and one-on-one informal sessions. All physician end-users were experienced with the hospital electronic health record. Clinical Transformation enabled through Information and Technology.
In July 2020, Mackenzie Health received funding approval from Ontario Health for a pilot project of the virtual Acute Respiratory Clinic (ARC) - remote monitoring of moderate risk (modified OSCI 3-4) COVID-19 patients with the goal of managing these patients at home and thereby diverting as many hospital admissions as possible during COVID-19 wave two and beyond.

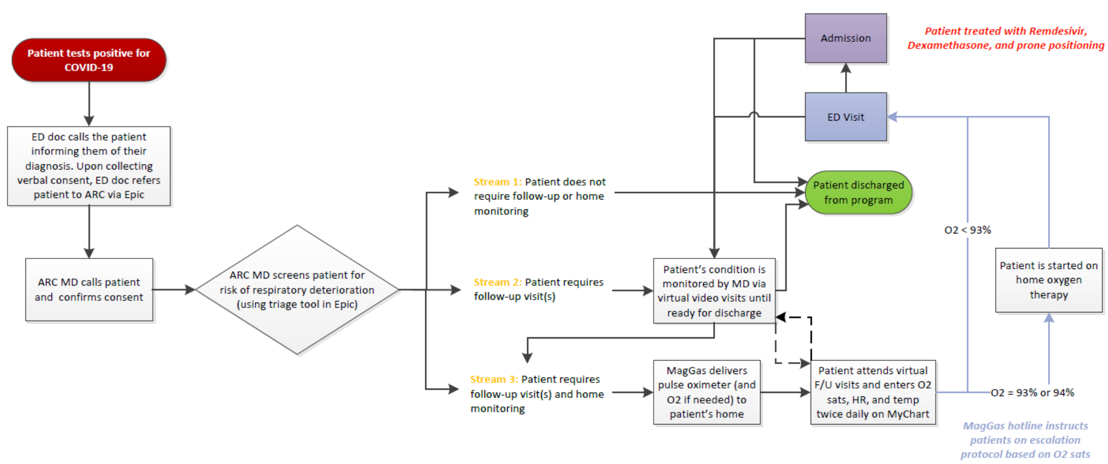

Figure 8. ARC simplified process diagram

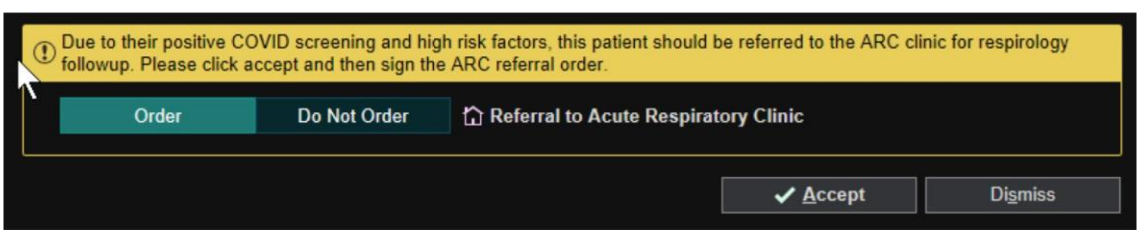

Figure 9. Best Practice Advisory triggered by clinical criteria.

A simplified process flow diagram of the clinic workflow can be found in Figure 4. Patients testing positive for COVID-19 at our ambulatory COVID Assessment Centre, Urgent Care Centre, or Emergency Department were triaged by ED physicians for hospital admission, discharge without referral, or referral to ARC for remote monitoring. For non-admitted patients, an automated algorithm was used to recommend ARC based on patient criteria (age >60 or age > 40 plus 1 or more risk factors). A Best Practice Advisory (**Error! Reference source not found.**) was utilized to recommend ARC referral for these patients. ED physicians could also independently refer patients to ARC based on clinical gestalt. Once the electronic referral was made, patients were assigned to an ARC work queue for appointment scheduling.

Due to the circumstances of the pandemic, we had to adopt a “no-frills” or “shoestring” approach to remote monitoring. Implementation of a telehealth system interoperable with the hospital EMR with automated data collection from digitally connected medical devices would have required additional time, budget, human resources, technical, privacy and security considerations. Clinician and patient training requirements would have been far more complex, and hands-on technical support would have been challenging due to pandemic restrictions and IPAC requirements. COVID-19 Wave 2 came much earlier than anticipated, which pushed the ARC clinic’s go-live forward by several months. The initial budget only provided for $220 CAD per patient including all overhead. Funding was low and the project used available resources to build the system (EMR) as it was the simplest and most cost-effective way to scale up. The oxygen saturation monitors were validated, and variation could be as much as 2%. Physicians used trending and symptoms as opposed to an absolute percentage to clinically treat these patients. With the unknown of the pandemic and the number of patients that would need to be monitored the project team chose this approach to maximize the funding that was available. As a result, cheaper oxygen saturation monitors were sourced at $60 per unit to maximize the funding available, limiting the need to return and clean the devices and to allow more patients to take part in the program. The whole kit including delivery fee and thermometer was $110. The ultimate solution and workflow consisted of:

1) A videoconferencing solution (Zoom Video Communications) for remote follow-ups. The initial plan had been for video follow-up of all patients but due to the high volume of referrals, as well as provider and patient preference, the majority of the follow-ups were conducted via telephone only.
2) Patients were provided with non-medical grade pulse oximetry devices (several retail brands) for recording of HR and SpO2. These devices were purchased in bulk from both local and online retail and had been locally validated for accuracy within 2% of a commercial grade or hospital grade pulse oximetry device (Philips SureSigns VS4). All patients were provided with simple instructions for use of the oximeter. Patients were supplied with oral or tympanic thermometers initially and later they supplied their own. Patients were given instructions on self proning to increase oxygen saturation.

3) Patient-entered discrete physiologic data (HR, SpO2, temperature) and symptom questionnaires via secure patient portal (hospital EHR). Patients were provided with instructions for access and use of the portal as well as online coaching by the virtual care providers during virtual visits. Alerts reminded patients to enter data every 12 hours. Patients were alerted when certain thresholds were entered and instructed on

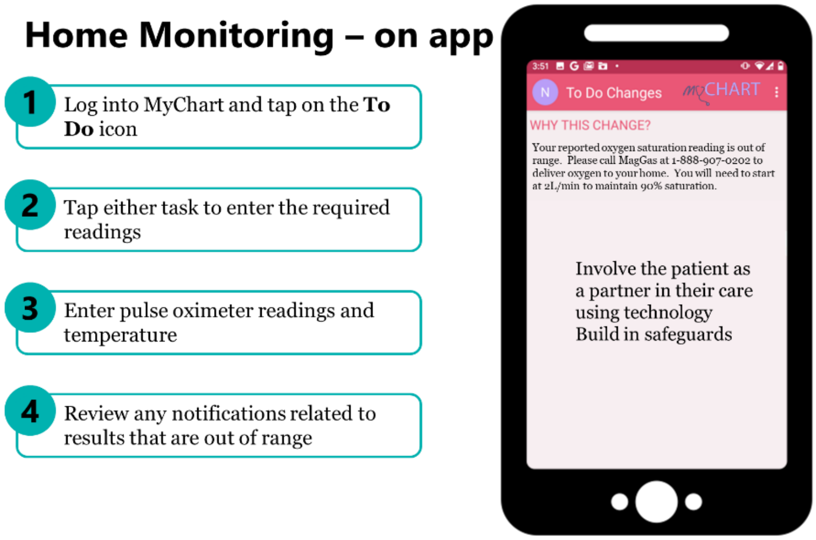

Figure 11. Patient home monitoring app

the next course of action. (Figure 6).

4) Automated threshold alerting (via color coded Synopsis) to physicians for key physiological derangement such as low oxygen saturation (Figure 7).

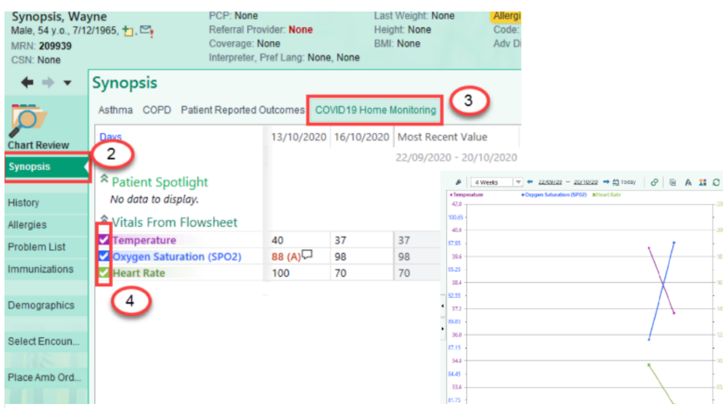

Figure 10. Synopsis with physiologic parameters

5) Physician-entered discrete physiologic, symptom, and functional status data and modified OSCI score. (Figure 8)

6) 24/7 hotline staffed by qualified respiratory therapists (MagGas) to support patients home monitoring questions. Patients with oxygen saturation less than 94% on room air were encouraged to initiate self-proning (resting in prone position to facilitate gravity-assisted lung recruitment) (Figure 9). Patients whose oxygenation did not improve with proning were referred for home oxygen delivery.

7) Home oxygen delivery for patients meeting high risk criteria (oxygen saturation less than 94% on room air) supplemented by daily check-ins in the first week of the program and then ongoing as required.
8) Patients that were started on home oxygen were also started on oral corticosteroid (dexamethasone 6 mg orally daily x 10 days) in accordance with in-hospital COVID-19 treatment guidelines. Paxlovid was not available during the study period. Remdesivir and other anti-viral and immunotherapies were in limited quantity and not available for outpatient administration during the study period.

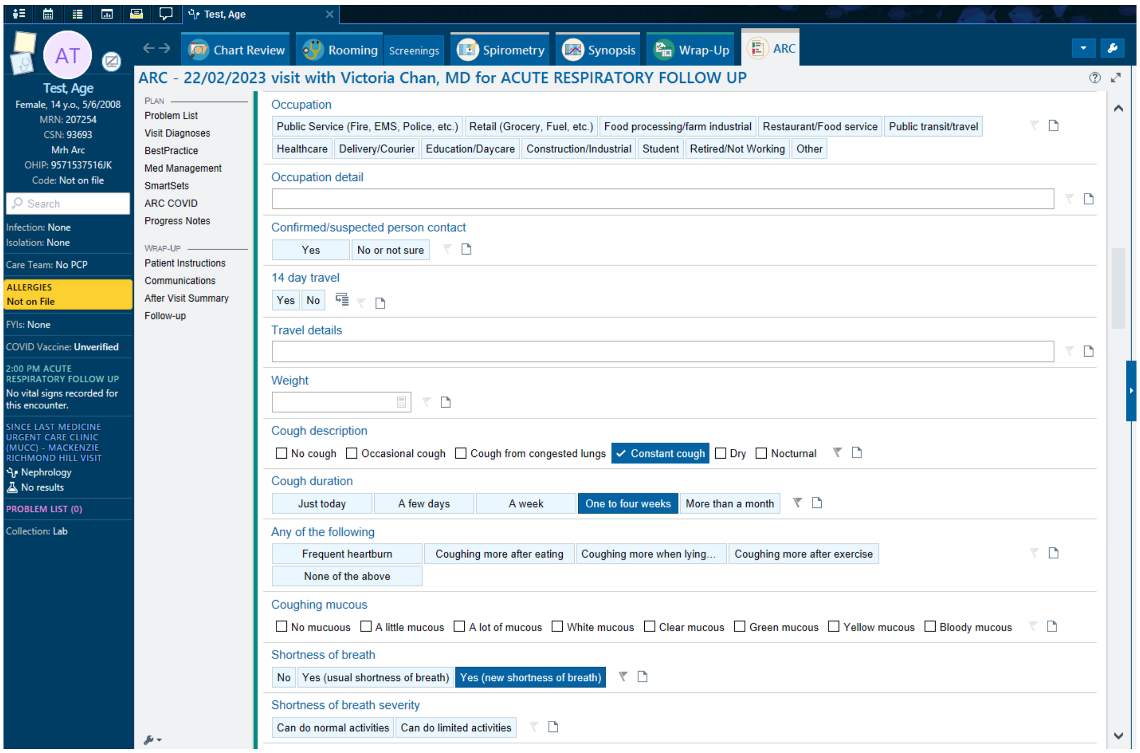

Figure 13. Physician visit navigator

As a failsafe, ARC patients were escalated for follow-up ED visits based on a triage algorithm (any of):
1) Spo2 less than 93% on 5L NP (max tank delivery)
2) One or more of severe chest pain, chest pressure, severe shortness of breath at rest with SpO2 greater than 93%,
3) Clinician concern. Patients referred to the ED for in-person assessment were screened for additional immunotherapy and admitted to hospital as needed.

Any of these escalations above required the patient to call the 1800 number of MagGas. Respiratory Therapists would answer the call and escalate appropriately. If the patient were required to come to the hospital, they would be instructed to arrange transport or call 911. Patients treated at home or presenting to ED for follow-up that required subsequent hospital admission were treated with the same hospital standard-of-care COVID-19 clinical pathway as patients admitted direct to hospital without ARC clinic referral. However, the treatments within the COVID-19 clinical pathway evolved during the pandemic/project due to treatment guideline changes by the Ontario

COVID-19 Science Advisory Table. The EHR inpatient and outpatient COVID-19 order inventories were updated frequently due to medication supply issues and changes to utilization criteria.

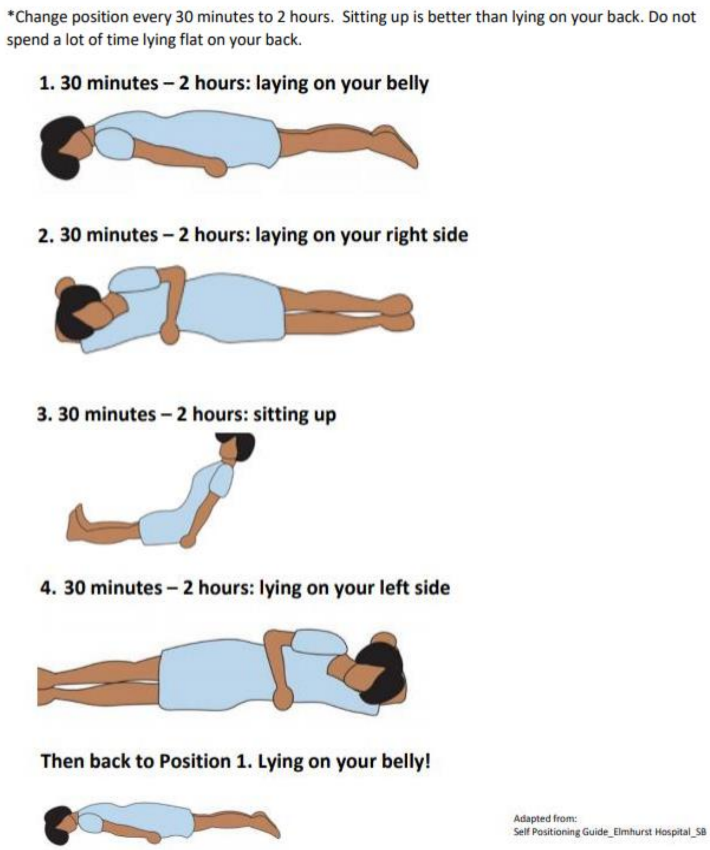

Figure 14. Prone positioning patient instructions

Improving Adherence to the Standard of Care

A feasibility assessment was conducted between June and August 2020. None of the patients required supplemental oxygen. The ARC clinic began formal enrollment in September 2020 and continued formal enrollment until June 2021 (Ontario COVID-19 Waves 2 and 3). At that time there was widespread availability of vaccine and COVID-19 hospitalization rates were in significant decline. All data was extracted from the EHR ARC clinic registry.

An ARC visit monitoring dashboard was configured in near real-time to capture via heat maps and trending information. The flowsheet data allowed tracking of data on the patient population to see if closures of certain industries were effective. Most of the patients caught COVID-19 according to self-reported data from home or family contact. Of the essential workers who were mandated to work the majority of cases from the workplace were contracted from construction or industrial locations. Tracking volumes helped to resource match the providers needed to keep on top of the cases. We found that each physician could carry about 10 to 15 cases. At the peak, the clinic deployed thirty-five physicians.

From the patient facing side, tracking their adherence informs the success of a remote monitoring program.

The ARC clinic was funded to enroll 1500 patients, but referral volumes far exceeded the initial funded capacity. By July 2021, a total of 6065 patients had been enrolled in the clinic and 10,236 virtual visits had been conducted (Figure 10). Thirty-five physicians

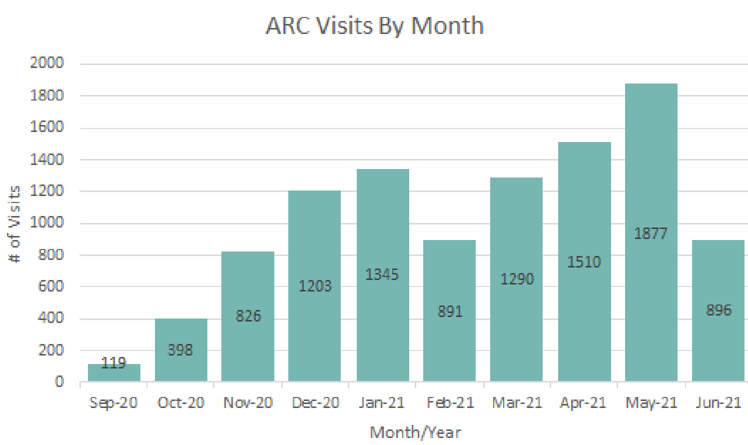

Figure 17. ARC virtual visits by month

specializing in either respirology or internal medicine as well as four community health nurses from SE Health, one of our Western York Region Ontario Health Team partners, performed the virtual visits.

There were more than 2700 patient calls triaged by the 24/7 hotline. 4705 patients met modified OSCI 1-2 criteria and had early discharge from the clinic. These patients were encouraged to recontact the ARC clinic if they experienced any worsening of symptoms or decline in oxygen saturation. 1360 patients received home monitoring kits. Of these patients, 739 were compliant with data collection and recorded a total of 23,858 entries. 203 patients were placed on home oxygen and received treatment at home with dexamethasone. Three hundred and sixty-six patients were triaged to in-person ED follow-up and 295 patients required subsequent hospital admission. There were 951 chest X-rays ordered and of these there were 641 patients who had infiltrates. Those with infiltrates were followed more closely for oxygen desaturation and requiring escalation.

Improving Patient Outcomes

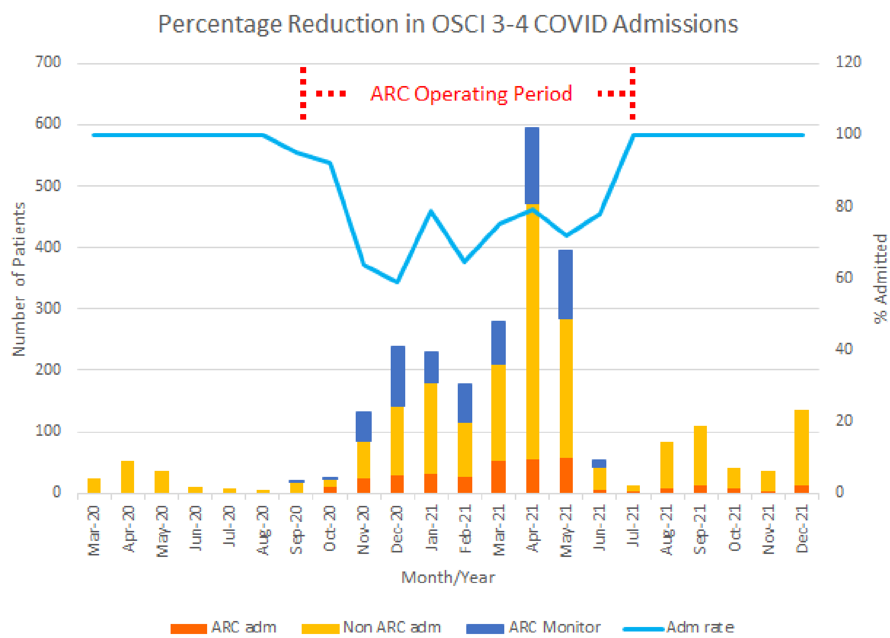

Figure 18. Reduction in OSCI 3-4 COVID-19 Admissions

The subset of patients who were deemed sick enough to require home monitoring ("ARC monitor") had modified OSCI 3-4/oxygen requirements and would otherwise have been admitted to hospital but were instead monitored closely by clinicians in the ARC clinic. Figure 11 shows the modified OSCI 3-4 hospital admission rate calculated as

$$\frac{\textit{Primary COVID patients admitted with modified OSCI } 3-4}{\textit{All admitted and non-admitted primary COVID patients with modified OSCI } 3-4}.$$

This figure compares only the OSCI 3 and 4 patients followed in the clinic vs the similar severity of cases admitted to the hospital. The classification of OSCI score is not absolute. There were OSCI 2 cases classified as limited by exercise who were also admitted or received oxygen. The remote monitoring clinic closed as cases waned and capacity issues at the hospital stabilized as the pandemic crisis lessened.

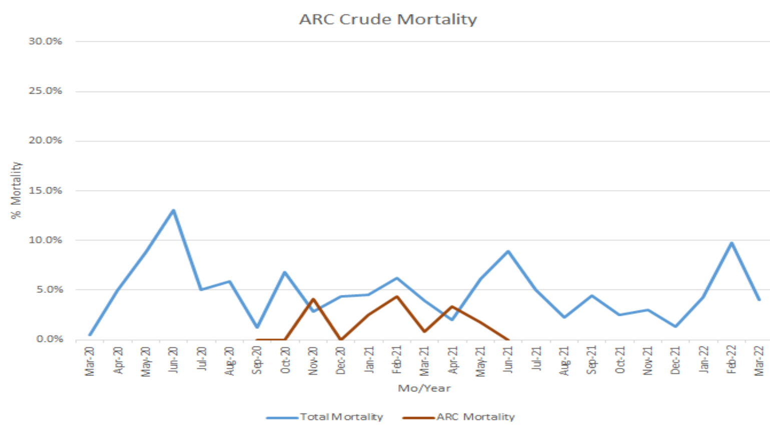

Figure 19. ARC crude mortality rate

Lessons learned from this project will be adapted as the hospital embarks on its Clinical Services planning specifically with Cardiac Clinic, Diabetes Education and the chronic kidney disease program. The initiatives mentioned are currently being scoped and the lessons learned from this remote monitoring program will be adapted so that we can maximize the functionality through our existing EMR with integration to low-cost solutions that worked with the patients as the program illustrated how patients were empowered to help manage their own care. There was concern that remote monitoring of patients outside the hospital would potentially delay hospitalization in deteriorating patients, and thereby contribute to increased mortality. **Error! Reference source not found.** shows the in-hospital crude mortality for patients that were remotely monitored through the ARC clinic and then subsequently hospitalized compared to the majority of patients that were directly admitted via the emergency department. Patients that were remotely monitored prior to hospitalization had a lower mortality rate than patients admitted directly from the emergency department. These patients had already failed low-flow oxygen therapy and initiation of glucocorticoid therapy prior to admission, the mainstays of treatment in the OSCI 3-4 patient population but did not have an increase in in-hospital mortality. We suspect that early outpatient treatment in this patient population contributed to the reduced mortality rate. Although the data is suggestive, it is not conclusive because we were not able to severity match the ARC patients with the non-ARC patients at time of admission.

System cost savings are traditionally segregated from patient outcomes. However, in a not-for-profit publicly funded hospital system, cost savings in any area translate directly into funding for additional patient care activities and consequently represent a direct benefit to patients. Despite the relatively small decline in percentage of hospitalization, a total of 1065 COVID-19 positive patients were diverted from hospital admission utilizing this "no-frills" approach to remote monitoring. In addition to providing increased capacity for provincial surge during the COVID-19 pandemic, there was a substantial system-wide cost savings. Each COVID-19 hospital admission costs $1137 CAD per day with an average LOS 3.8-6.9 days (depending on need for ICU admission). Diverting 1065 patients from hospital admission represents a total savings of $4.3-7.8 million CAD.

Accountability and Driving Resilient Care Redesign

As with all activities during the COVID-19 pandemic, workflow redesign was driven by rapidly changing priorities, advances in clinical evidence, and an ongoing need for reallocation and redeployment of organizational resources. As part of the organizational enterprise analytics program, an analytics dashboard was used to monitor ARC activity in near-real time (Figure 13). The percentage of ED escalation relative to distinct patient

Figure 20. ARC dashboard examples

visits averaged 4.96% (2.68%-7.56%) and escalation to admission averaged 2.57% (0.56% to 4.03%). Throughout the running of the clinic these percentages remained low.

COVID-19 vaccination in Canada for seniors began in mid-December 2020. Prior to that, the highest at-risk population for hospitalization was in age > 60. A near real-time analysis of COVID-19 hospitalizations during Ontario COVID-19 Wave 2 demonstrated a shift in the

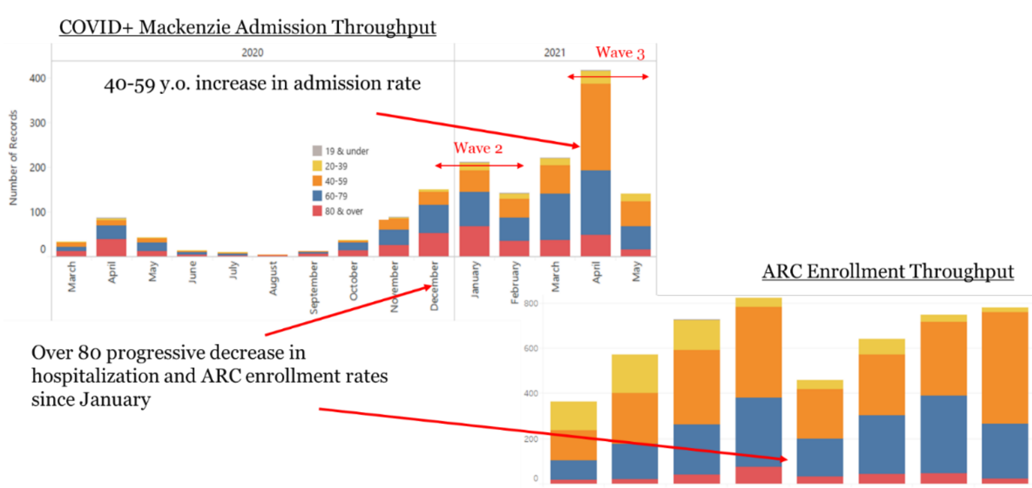

Figure 22. ARC adapted enrollment criteria to meet changing admission demographics.

at-risk population over time, with an increasing proportion of patients aged 40-59 (Figure 14).

As a result of this analysis, the ARC referral criteria were expanded to include patients aged 40-59 in the triage protocol.

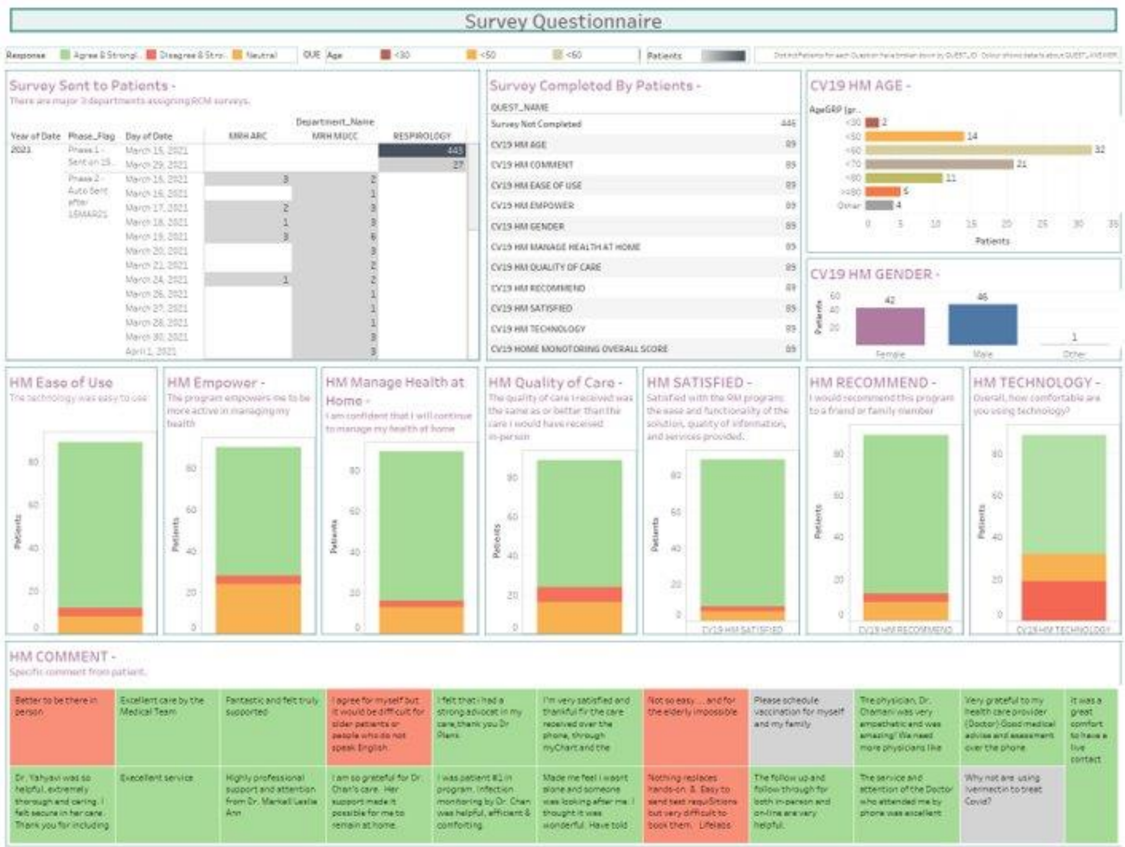

Fig 15

A patient satisfaction survey was conducted in the spring prior to the conclusion of the clinic. Eighty-nine patients responded. Ninety one percent (81/89) patients were satisfied with the program, with 86.5% reporting satisfaction with “ease of use”. Most patients 85% would recommend this program to family or friends while 69.7% of patients felt empowered and 69.7% rated the quality of care to be the same or better than in person. There were comments such as “I felt supported,” that “service and attention excellent,” “highly professional” and “follow up and follow through in person and online very helpful.”

Case Study: Key Take Away

Prior to the initiation of this project, we had assumed (like most other organizations) that a comprehensive remote monitoring program required a significant investment in medical devices, device interoperability platform, and a substantial commitment of hospital resources. In this case study, we have demonstrated the feasibility, clinical, and financial benefits of a “no-frills” approach to remote monitoring utilizing the basic functionality of the EHR patient portal with patient-collected data, threshold notifications, and simple triage algorithms. Although this approach was taken due to the specific circumstances of the COVID-19 pandemic, organizations with limited budget or resources should consider this simplified approach to remote monitoring as a first step to achieving value realization from health technology. This information was shared with Ontario Health as one of the requirements of funding granted to hospitals for programs such as this is to share with GTA, provincial and national hospitals. As a result of this program there were other hospitals in the GTA that adopted our strategy for remote care monitoring of COVID-19 patients.