As the Covid-19 pandemic accelerated in the US, Northwestern Medicine recognized a need to support the numerous patients who would care for themselves at home. We wanted to assess patients daily, provide advice, and facilitate additional care for those with concerning, worsening, or severe symptoms.

We developed a monitoring program that delivers a daily electronic symptom and coping questionnaire, uses text message reminders, and relies on telephone-based care. Within 10 days, we organized 193 nurses, 70 advanced practice professionals, 152 medical students, and 115 physician attendings to care for about 1000 patients per day using an electronic health record registry. As of May 21, 6,853 individuals had been through the monitoring program. We have averaged sending nine patients per day to emergency departments. Challenges include standardizing workflows, reaching patients, and balancing workforce with patient volume. In the accelerating pandemic, proactive monitoring of Covid-19 patients has helped our health system, employees, and patients. Future directions include developing sustainability and better integration with primary care.

Most patients with Covid-19 have a benign course, do not require hospital level care, and can self-isolate and treat themselves at home.1,2 Patients with a severe course generally worsen after many days of home-managed mild to moderate illness.3 Early in the pandemic, a high proportion of patients with presumed Covid-19 could not or did not require testing.4 Many institutions recognized the need to develop processes and capacity to accommodate the anticipated surge of emergency department (ED), inpatient, and intensive care unit patients. At Northwestern Medicine – an integrated academic health system with 10 hospitals and over 200 sites throughout Chicagoland – we also recognized a need for an initiative to implement systematic monitoring and support of patients at home.
We developed and implemented a dynamic registry of adult ambulatory patients with pending or positive SARS-CoV-2 testing or presumed Covid-19 based on clinical criteria. Our goals were to: provide patients with home-based monitoring, clinical care, and support; off-load burden from primary care practices; develop a platform that could support outpatient observational or interventional research.

**Development and Initial Implementation**

Covid-19 was first reported by the Illinois State Department of Public Health on January 24 in a person who had traveled from China, and then in her husband. This discovery was followed by several isolated travel-related or family-linked cases in February. Between March 8 and March 10, a series of cases was identified without clear linkage to travel, signaling the arrival of the pandemic in Illinois.

We also engaged faculty from the Department of Medical Social Sciences who have expertise in symptom assessment and patient-reported outcomes and quickly developed a short, easily understandable questionnaire that captured the main domains of patients’ symptoms and experience with Covid-19 at the time.

We first discussed an intensive patient outreach and follow-up program on March 17, and the work of several groups quickly came together. We obtained the support of our chief quality officer, chief medical officers, Northwestern Medical Group president, and vice dean for education. Information technology staff began building a registry and questionnaire based on our Epic electronic health record. We also engaged faculty from the Department of Medical Social Sciences who have expertise in symptom assessment and patient-reported outcomes and quickly developed a short, easily understandable questionnaire that captured the main domains of patients’ symptoms and experience with Covid-19 at the time. (Note: Though the Covid-19 symptom picture has evolved over time, we elected to keep our questionnaire consistent for data consistency and ease of use.)

Initially, educational faculty put us in touch with about 60 fourth-year medical students whose clerkships were on hold and who were eager to contribute. Other fourth-year students finishing clerkships and third year students subsequently joined the program. To supervise the medical students, we recruited primary care physicians, specialists, and other physicians who were quarantining after Covid-19 exposure, could not do face-to-face work based on personal risk, or were recently retired.

We went live on March 24. On March 27, we engaged furloughed nurses and advanced practice professionals (APPs -- physician assistants and nurse practitioners).
To limit the number of patients in the registry and to ensure consistent adherence to the entry criteria, our clinical criteria and processes were intentionally specific. Patients were included in the registry if they had a pending Covid-19 test, a positive or indeterminate Covid-19 test, or presumed presence of Covid-19 based on clinical criteria. The clinical criteria included fever > 100.4°F (38.0°C), a new respiratory symptom or diarrhea, lack of an alternate diagnosis, and a high-risk feature (age ≥ 65 years old or a chronic medical condition). We excluded inpatients. Only nurses from our Covid-19 triage phone line, ED staff, and hospital medicine staff were able to add patients to the registry. (Table 1)

At 6 a.m. each day, enrolled patients with an EHR portal account receive a questionnaire invitation. The initial questionnaire asks about the date symptoms began, the presence or absence of 10 symptoms, information about the household, and an alternate contact person. On the initial questionnaire and each day subsequently, patients are asked to evaluate 10 symptoms rated on a zero to 4 scale (from “not at all” to “very much”) how they feel the infection is affecting them, how many analgesic/antipyretic tablets they are taking, and a measured temperature (Figure 1).
We use responses from the daily symptom questionnaire to stratify patients into those with mild symptoms (0, 1, or 2 responses to most questions) and those with concerning symptoms (mostly 3 and 4 responses to some questions). Nurses, APPs, and medical students call patients who report concerning symptoms, those who do not fill out the questionnaire because they are not enrolled in the patient portal, and those who have not responded by about 11 a.m.

### Daily Outpatient COVID-19 Monitoring Questionnaire

Below is a list of statements that other people with your illness have said are important. Please circle or mark one number per line to indicate your response as it applies to the past 24 hours.

| Symptom                                      | Not at all | A little bit | Some what | Quite a bit | Very much |
|-----------------------------------------------|------------|--------------|-----------|-------------|-----------|
| I have been coughing                         |            |              |           |             |           |
| I have been short of breath                  |            |              |           |             |           |
| I have a sore throat                         |            |              |           |             |           |
| I have muscle aches                          |            |              |           |             |           |
| I have trouble sleeping at night             |            |              |           |             |           |
| I have a lack of energy                      |            |              |           |             |           |
| I feel ill                                   |            |              |           |             |           |
| I have had fevers                            |            |              |           |             |           |
| I have diarrhea                              |            |              |           |             |           |
| I have pain in my stomach area               |            |              |           |             |           |
| I feel overwhelmed by my condition           |            |              |           |             |           |
| I worry that the infection will get worse    |            |              |           |             |           |
| I worry about spreading my infection         |            |              |           |             |           |

How many pain or fever-reducing pills (like Tylenol or Ibuprofen) have you taken in the last 24 hours? [enter whole number]

What is the highest your temperature has been in the past 24 hours? [enter temperature]

Since you have been monitored, has anyone else in your household developed fever AND a new respiratory symptom?: Y/N

Source: Northwestern Medicine and the authors

NEJM Catalyst (catalyst.nejm.org) © Massachusetts Medical Society
Our initial plan was to follow patients until a) they had symptoms for seven days and minimal symptoms for three days (indicating that their overall illness would likely be mild), b) they were hospitalized, or c) we could not reach them for seven days. We found that the seven-day monitoring was unnecessary for patients who had mild symptoms, and also that if we couldn’t reach patients after three days, they were effectively unreachable. Subsequently we revised our “graduation criteria” to include patients who had minimal symptoms for three days or could not be reached for three days, to reduce the time spent chasing after patients who could not be reached or monitoring those who were not severely ill enough to benefit from our intervention.

**Patient Assessment and Assistance**

During the calls, medical students, nurses, and APPs evaluate patients for the presence of severe symptoms, answer questions, provide information, determine whether contacting other clinicians might be helpful (e.g., a primary care physician or specialist), reinforce the need for self-isolation, and identify non-clinical issues that might be routed to a social worker. Primary care and specialty attending physicians answer questions from the students and nurses and evaluate more complicated patients. Patients with severe symptoms – shortness of breath, confusion, signs of hypoxia, or persistent chest pain or pressure – are referred to the ED. If they need emergent transport, we call 911.

**Workforce**

The program operates from 8 a.m. to 8 p.m. seven days a week. An average of 90 different nurses, APPs, and medical students work four-, eight-, or 12-hour shifts for an average of roughly 500 staffed person-hours per day. Three attending physicians, working four-hour shifts, provide clinical supervision, for a total of nine attendings per day. Each team member receives training before their first shift, which includes orienting to the program and its goals, setting up EHR tools, and modeling the telephone call workflow. Nurses and APPs, whose usual clinic sites are closed or have reduced staffing because of the pandemic, are paid their usual hourly rate.

By April 3rd, we had three leads supervising and coordinating the work. To communicate, we grouped the calls based on the first letter of patients’ last names and used Microsoft Teams to coordinate during the day. The medical students initially communicated with each other and their attending physicians using email or Zoom, but gradually transitioned to Microsoft Teams (the preferred health system communication platform) as well.

**Metrics**

We went live mid-day on March 24 with 50 patients. Within 8 days, we were following roughly 1000 people per day (*Figure 2*) and, as of May 21 we had reached 6,853 unique individuals.
Patients in the Northwestern Outpatient COVID-19 Monitoring Program over Time

- Total patients
- New patients
- Existing patients
- Completed program

Source: Northwestern Medicine and the authors
NEJM Catalyst (catalyst.nejm.org) © Massachusetts Medical Society

Other observations about the program (Figure 3; Figure 4):
FIGURE 3

Daily Symptom Score

Source: Northwestern Medicine and the authors
NEJM Catalyst (catalyst.nejm.org) © Massachusetts Medical Society
Employees from our health system make up about 20% of those monitored.

Average symptoms were mild, about 12 on a scale of 0 to 52, and, for individual patients, decreased over time.

Of those who filled out a questionnaire, on any given day, about 20% reported concerning symptoms.

An average of 9 patients per day went to the ED (SD, 5; range, 1 to 21).

After April 11, when we instituted stricter “graduation” criteria to remove patients who had had minimal symptoms or whom we were unable to contact for 3 days, we began to see a decrease in the number of patients in the program. On May 1, we made changes our inclusion logic, including patients with a “Covid-19 infection flag,” associated with an outside positive test, which led to a temporary increase in patient volume. On May 6, as our institutional testing criteria expanded and our testing volume increased, we began only including patients who had a positive Covid-19 test.
Challenges

There have been many challenges to implementing this program. They include:

**Variable patient engagement.** Although we encourage all patients to sign up for the patient portal, about one-third do not. Despite EHR portal messages, texting, and phone calls, about 20% of patients do not fill out the questionnaire each day. Patients with minimal symptoms sometimes express annoyance at being contacted. Some patients expressed frustration at the lack of testing availability. However, more patients each day express gratitude that the students and nurses are following up, providing reassurance and helping them address loneliness. Patients often want to stay on the monitoring program even after they have met our stopping criteria, and we ease them out as gently as we can, so as to keep adequate capacity for incoming patients.

**Balancing the available workforce with the clinical need.** We quickly expanded the program from 5 medical students per shift to about 50 nurses, APPs, and medical students per shift. Nurses, who are used to operating under protocols, become very efficient once they understand the program guidelines. However, they often seek reassurance that they are applying rules properly. Medical students tend to seek support and reassurance for clinical decision-making. The medical students, nurses, and APPs have been supportive of one another and are happy to be contributing to the Covid-19 response, especially those who cannot contribute “on the front lines.” Participating in the program has been an important learning opportunity for them as we learn how to best advise patients on managing Covid-19 at home. Medical students can get educational credit for their participation as part of a “virtual clerkship” in Emergency Medicine or Primary Care, which helps fulfill graduation requirements.

**Lack of timely data.** Technical challenges have included use of a registry that does not update in real time and takes about an hour to refresh completely. This delay requires staff to look in individual patients’ charts to see if someone else is actively working on that chart. At one point, changes in the registry (e.g., questionnaire completion, call status) were queuing up faster than our system could process them. We improved performance by spacing out registry updates from every five minutes to every ten minutes, asking all users to promptly close their encounters, and doubling processing power. In addition, after about a week, we realized we had not published two fields in the daily questionnaire (“fever” and “feeling ill”) and we missed collecting those data on some patients, though this gap has not caused any issues with subsequent analysis.

Next Steps and Conclusions

From a financial perspective, we are internally funding the monitoring program and not billing patients or payers. We will need to determine at some point whether the financial cost has been worth the clinical value to our patients, though the calculation is extremely complex due to the unique circumstances of the coronavirus pandemic.

“Anecdotally, we are helping patients live more comfortably at home, providing them with education, reassurance, and comfort.”
Anecdotally, we are helping patients live more comfortably at home, providing them with education, reassurance, and comfort. We also helped patients who needed to have 911 activated, including one who was triaged to the ED and immediately put on a ventilator. Although the program seems to be the right service to provide – connecting sick patients at home with care – we have not been able to conduct a robust-learning health system effectiveness evaluation.9,10

We plan to layer observational and interventional research projects on the Ambulatory Monitoring Program, including studies of predictors of a severe course, home monitoring technology, treatments for Covid-19, and identification of patients who can participate in longer-term research or donation of convalescent plasma. Even after the Covid-19 pandemic eases, the outpatient home monitoring program may provide a prototype for efficient management of other acute problems or other problems where clinical deterioration is possible. Future versions should benefit from patient engagement tools, automation, artificial intelligence, and better integration with primary care.

Gayle Kricke, MSW, PhD
Director of Operations, Primary Care Administration, Northwestern Medical Group Assistant Professor, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

Phillip E Roemer, MD
Chief Medical Officer, Northwestern Medical Group Assistant Professor of Medicine, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

Cynthia Barnard, PhD, MBA
Vice President, Quality, Northwestern Memorial HealthCare Assistant Professor, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

John Devin Peipert, PhD
Assistant Professor, Department of Medical Social Sciences, Northwestern University Feinberg School of Medicine

Bruce L Henschen, MD
Assistant Professor, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

Jennifer A Bierman, MD
Associate Professor, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

David Blahnik,
Director Information Technology, Northwestern Memorial Hospital
Michael Grant,
Information Systems Team Lead, Northwestern Medicine

Jeffrey A Linder, MD, MPH, FACP
Professor and Chief, Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine

Acknowledgements

We acknowledge contributions of other leaders, medical students, faculty, nurses, and information technology staff in developing and implementing this system and caring for our patients. We acknowledge the contribution of David Cella, PhD, for his advice in developing the symptom questionnaires. To monitoring program patients, we sincerely hope we are providing useful service, care, and comfort and hope you are doing well.

Disclosures: Gayle Kricke, Philip Roemer, Cynthia Barnard, John Devin Peipert, Bruce Henschen, Jennifer Bierman, David Blahnik, Michael Grant, and Jeffrey Linder have nothing to disclose.

References

1. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA.

2. Gandhi RT, Lynch JB, Del Rio C. Mild or Moderate Covid-19. N Engl J Med.

3. Zhou F, Yu T, Du R. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395(6):1054-62

4. NEJM Catalyst. What Health Care Leaders and Clinicians Say About the Covid-19 Pandemic. 2020. https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0177

5. Ghinai I, McPherson TD, Hunter JC. First known person-to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the USA. Lancet. 2020;395(6):1137-44

6. Covid-19 Statistics. https://www.dph.illinois.gov/covid19/covid19-statistics. Accessed May 1, 2020.

7. FACIT.org. https://www.facit.org/FACITOrg. Accessed April 28, 2020.

8. Little P, Stuart B, Moore M. Amoxicillin for acute lower-respiratory-tract infection in primary care when pneumonia is not suspected: a 12-country, randomised, placebo-controlled trial. Lancet Infect Dis. 2013;13(6):123-9

9. Grumbach K, Lucey CR, Johnston SC. Transforming from centers of learning to learning health systems: the challenge for academic health centers. JAMA. 2014;311(6):1109-10
10. A Chicago Center of Excellence in Learning Health Systems Research Training (ACCELERAT). https://www.capricorncdrn.org/projects/a-chicago-center-of-excellence-in-learning-health-systems-research-training-accelerat/. Accessed April 28, 2020.