



The Virtual Hospital at Home—Denver Health’s Experience Treating COVID-19 Patients Remotely

HIGHLIGHT

*Denver Health is a Level 1 Trauma Center and Urban Safety Net hospital with 550 beds and nine federally qualified community health centers located throughout the city. Before the pandemic, the hospital had 227 adult medical surgery/critical care beds, 47 were intensive care unit (ICU)-level beds, and 12 were intermediate care beds. They ran near or at capacity and often experienced adult emergency department boarding. **Patrick Ryan, MD, MPH**, and **Connie Savor Price, MD** (from Denver Health and the University of Colorado School of Medicine) shared their experiences creating the “Virtual Hospital at Home” model to manage the significant surge in COVID-19 patients in the fall of 2020.*

■ Connie Savor Price (CSP)

In the spring of 2020, we were running near capacity, with large numbers of sick COVID-19 patients. We had stopped elective procedures and routine clinic visits, primarily because we wanted to conserve personal protective equipment (PPE) and better manage patient surge. Our biggest “pain point” at first was the ICU beds; many more patients were going to the ICU earlier in the pandemic. To make space, we converted a unit that had been used for medical surgery and intermediate care into a flexible medical surge unit, and we housed intermediate and critical care patients together in that one unit. Our pediatric census was relatively low, so we also consolidated that unit and used the extra beds for adult patients.

We created our initial surge plan, and as time went on, we developed the virtual hospital at home plan and incorporated it into our surge plan.

In the fall of 2020, we had returned to more traditional operations. We cared for patients who deferred their medical issues or put off treatment in the spring, or whose elective procedures had been canceled, and we had an increase in both non-COVID and COVID-positive patients. This time, our pain point was in our med/surgery unit, not ICU.

We permanently converted our overflow Women and Children Unit to increase capacity for adult patients, privileged pediatricians so they could treat patients up to age 30, and we allowed those patients to be placed in pediatric units as

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long as they met certain criteria. To offload our ICU, we adjusted some protocols to allow our respiratory therapists to use heated high flow oxygen on the general medicine ward.

These modifications to the surge plan and having adequate PPE allowed us to address our surge levels and switch to manage staffing considerations. We were dealing with incredibly fatigued staff and the entire country was affected by this second surge, making travel staff in short supply. We did try to recruit temporary staff, and we then received an executive order from Colorado's governor to demonstrated we could increase our hospital's capacity by 50 percent.

In response, we created a table that illustrated how we could increase capacity. This was broken down by critical care beds, intermediate care beds, med/surgery beds and the capacity added by the Virtual Hospital at Home (VHH) model (Table 1).

Table 1. Denver Health's Seven Levels of Capacity

Level	Special Pathogen status	Critical Care beds	Intermediate Care beds	Med/Surge beds	VHH*
Level 1 Hospital beds:* 227 (2019)	Special Pathogen +/- (hybrid)	MICU - 24	PCU - 12	0	N/A
	Special Pathogen -	SICU - 23	0	9A - 36 8A - 36 7A - 28 6A - 20 4B - 30 3B - 18	
Level 2 Hospital beds:* 255 VHH: 38 (Spring 2020)	Special Pathogen +/- (hybrid)	MICU - 24 3B - 4	3B - 21	9A - 36 3B - 5	38
	Special Pathogen -	SICU - 23	0	8A - 36 7A - 28 6A - 31 4B - 30 4C South - 17	
Level 3 Hospital beds:* 255 VHH: 45 (Fall 2020)	Special Pathogen +/- (hybrid)	MICU - 24 3B - 6 SICU - 6	3B - 18	9A - 36 3B - 6 4B - 30	45
	Special Pathogen -	SICU - 17	0	8A - 36 7A - 28 6A - 31 4C South - 17	
Level 4 Hospital beds:* 255 VHH: 45	Special Pathogen +/- (hybrid)	MICU - 24 3B - 12 SICU - 6	3B - 18	9A - 36 4B - 30	45
	Special Pathogen -	SICU - 17	0	8A - 36 7A - 28 6A - 31 4C South - 17	
Level 5.1 Hospital beds:* 267 VHH: 45	Special Pathogen +/- (hybrid)	MICU - 24 3B - 12 SICU - 6	3B - 18	9A - 36 4B - 42 (12 double rooms)	45
	Special Pathogen -	SICU - 17	0	8A - 36 7A - 28 6A - 31 4C South - 17	
Level 5.2 Hospital beds:* 279 VHH: 50	Special Pathogen +/- (hybrid)	MICU - 24 3B - 18 SICU - 6	3B - 12	9A - 36 4B - 54 (24 double rooms)	50
	Special Pathogen -	SICU - 17	0	8A - 36 7A - 28 6A - 31 4C South - 17	
Level 6 Hospital beds:* 323 VHH: 60 - 70	Special Pathogen +/- (hybrid)	MICU - 24 3B - 30 SICU - 6	4B - 12	9A - 62 (double/triple rooms) 4B - 36 (18 double rooms)	60 - 70
	Special Pathogen -	SICU - 17	PreOp - 10	8A - 36 7A - 28 6A - 31 4C South - 17 5W - 14	
Level 7 Hospital beds*: 352+ VHH: 60 - 70	Special Pathogen +/- (hybrid)	MICU - 24 3B - 30 4B - 30 SICU - 6	0	9A - 62 (double/triple rooms) 8A - 36+	60 - 70
	Special Pathogen -	SICU - 17	PreOp - 20 PACU - 17	7A - 28+ 6A - 31+ 4C South - 17 5W - 14 2M - 20	

The VHH program cared for a total of 1,260 patients between April 2, 2020 and the closing date (March 7, 2021).

The highest level we reached in the fall was 5.1. To meet those numbers, we doubled up rooms in med/surgery and used the VHH program to care for some of these patients who would have otherwise taken one of those beds.

■ Patrick Ryan (PR)

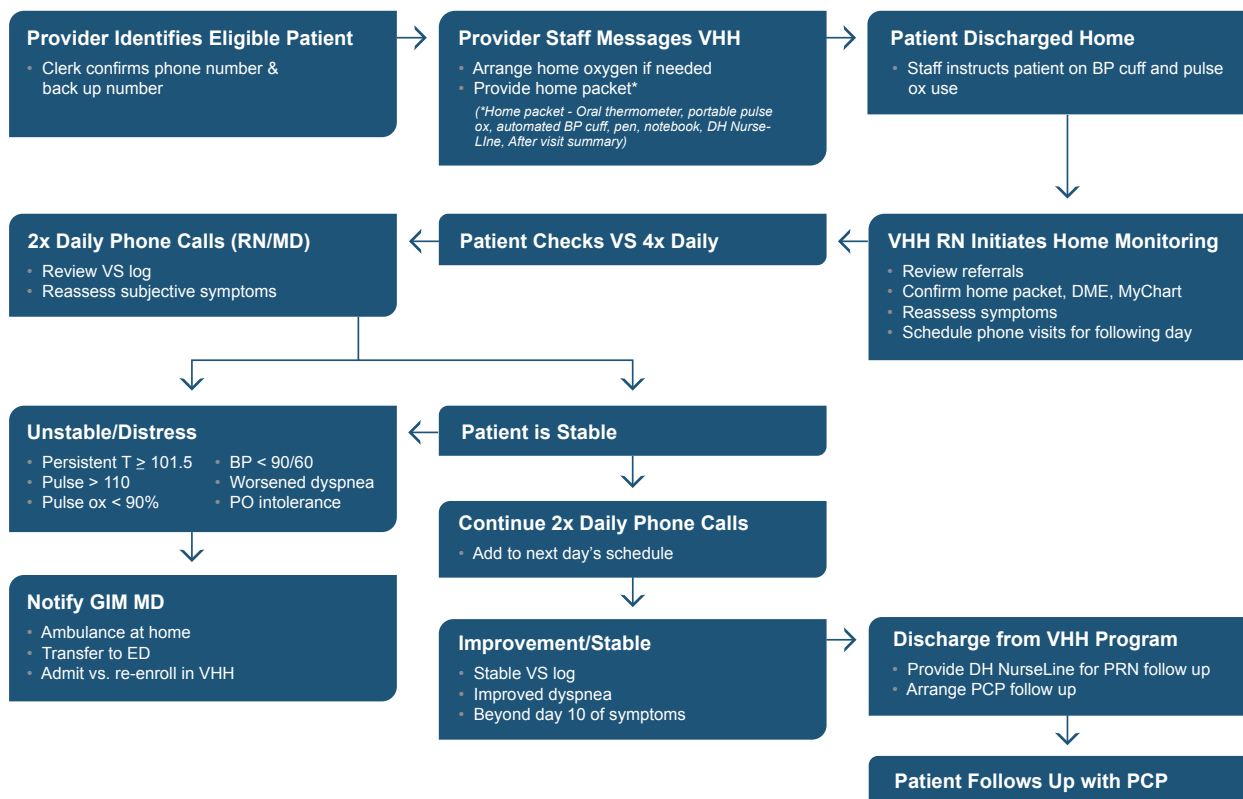
I have been working on the VHH program since it was developed in March 2020. The program was developed through interdepartmental collaboration with our emergency department, inpatient medicine, general internal medicine, and infectious disease colleagues. One of the things we were most worried about early in the pandemic was running out of beds and having to turn patients away. We hoped that developing the VHH program would help us identify patients at high risk of severe COVID infections, be able to manage them at home, and free up inpatient hospital beds. We also thought this model would allow us to discharge patients earlier in their courses to free up beds. We believed that increasing support at home would also decrease emergency department visits and rehospitalization.

We used a risk factor-based model to determine our target population for VHH. Patients had to be at high risk for more severe infection and had to have two or more of the following risk factors:

- Age > 65
- Chronic Kidney Disease
- Chronic Artery Disease
- Congestive Heart Failure
- Hypertension
- End-stage Liver Disease/Cirrhosis
- Chronic Obstructive Pulmonary Disease (COPD)/Asthma
- Malignancy
- Obesity
- Diabetes
- Immunocompromised

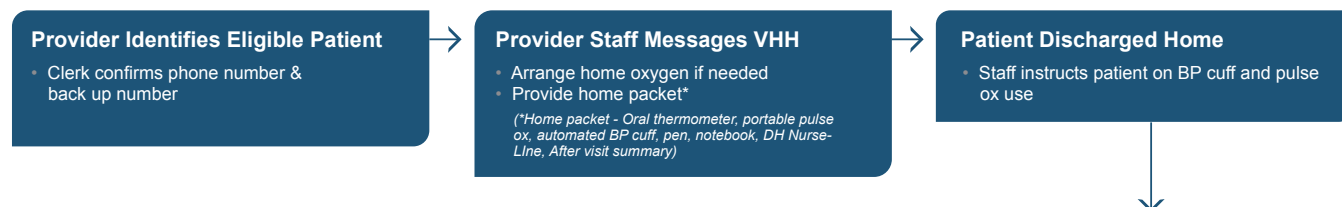
These were general guidelines for providers; they were able to use their discretion when referring patients to the program. Over time, we expanded the referral criteria to include any patients placed on oxygen therapy or who had increases in their baseline oxygen therapies. VHH was not a substitute for inpatient care; it was an aggressive remote home monitoring program and encounters were billed as outpatient visits, not hospitalizations. Figure 1 illustrates a high-level overview of VHH workflows.

Figure 1. Overall VHH Workflows



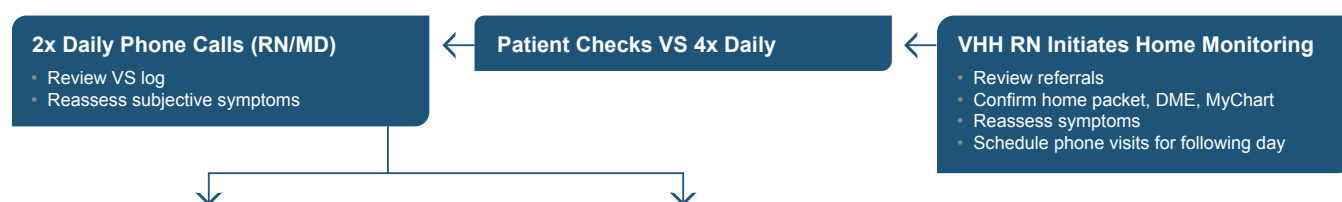
As illustrated in Figure 2, a provider (typically from the emergency or inpatient departments, urgent care, or primary care) identifies an eligible patient (with suspected or confirmed coronavirus infection). Because the entire platform is built solely on the use of a telephone, we have a staff member confirm the patient's phone number and a backup number to ensure we are able to contact patient. The provider would then message our VHH in-basket pool within the patient's electronic health record (EHR), providing additional detail on the patient and any current concerns. The patient was then provided a "home packet" comprised of an oral thermometer, pulse oximeter, blood pressure cuff, and writing utensils so they could record their vital signs. We also provided instructions for using this equipment in the packet.

Figure 2. Phase 1 of the VHH Workflow Process



Next, the VHH home team would receive that email referral through the EHR and confirm that the patient had the home monitoring equipment and access to "My Chart," the patient portal that gave access to the EHR. As demonstrated in Figure 3, patients received phone calls to assess symptoms. We requested that patients check and record their vital signs four times a day. Patients received twice daily phone calls, one from a registered nurse (RN) and the other from a provider (MD, DO, PA, or NP). Patients might receive an RN call in the morning and a call from the provider in the afternoon (or vice versa). We staggered these calls because we learned early on that some patients might sound great in the morning, then worsen (e.g., become extremely short of breath, have saturation levels close to 80%) in the afternoon. Staggering helped us identify decompensation early in their course and get them escalated care, preventing severe events at home.

Figure 3. Phase 2 of the VHH Workflow Process

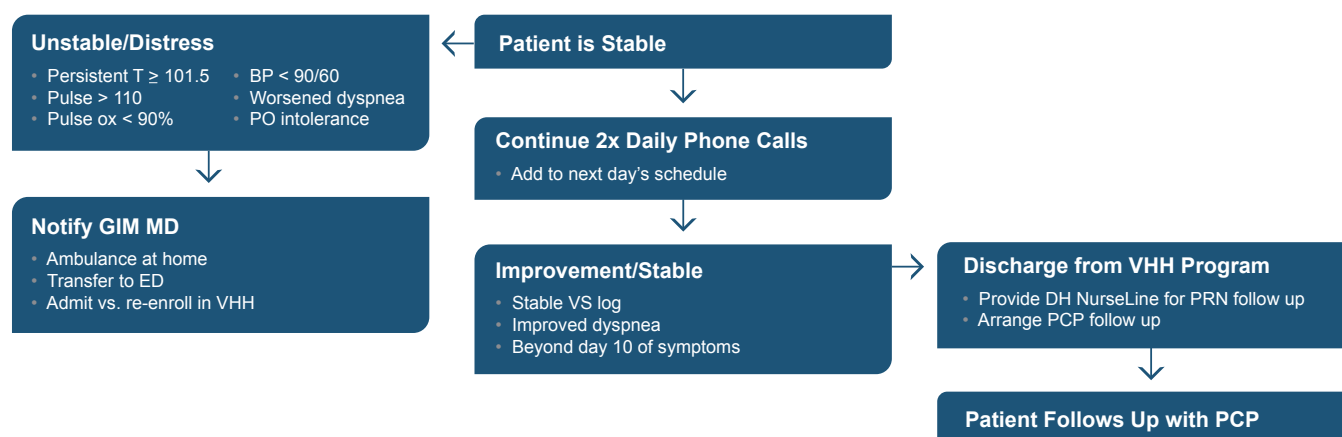


Links to Denver Health VHH Forms:

- [VHH Patient Packet Instructions](#)
- [VHH Home Monitoring Patient Guidance](#)
- [VHH Vital Signs Tracker](#)
- [VHH Emergency Department Checklist](#)

As shown in Figure 4, assuming patients were stable (their breathing and vital signs improved, and they were beyond day 10 of their symptoms), we continued twice a day phone calls for the duration of their treatment. Patients were then discharged from the program with instructions, including contact information for the Denver Health NurseLine for after-hours care and we arranged follow up with their primary care provider. If patients did not have a primary care provider at Denver Health, we helped them locate one.

Figure 4. Phase 3 of the VHH Workflow Process



If patients were not stable or had continued concerning symptoms or vital signs (e.g., they had a persistent temperature at or greater than 101.5 degrees, their pulse rate exceeded 110, pulse ox was less than 90%, and the like), the attending (typically a general internal medical doctor, or GIM) who was part of the VHH that day was notified and would either call the patient themselves to assess or arranged to transfer the patient to the emergency department. Providers communicated and made decisions via a group chat function in the EHR. Our medical assistants, clerks, RNs, and physicians all participated in the group chat. This was where we discussed patient needs, coordinated ambulance transport from patients' homes, and notified the emergency department that a patient was coming.

Our staffing was dependent upon outpatient primary care physicians. The general internal medicine department took the lead in staffing the VHH, and we eventually included some colleagues from family medicine, too. Some of our urgent care providers who worked on a PRN basis also participated in the team. RNs were pulled from their normal clinical responsibilities to staff the VHH. Some resident physicians worked with us when they could not work in the hospital in person (either due to contact tracing or because they were at high risk for infection). We also pulled medical assistants and care navigators who were key in getting patients scheduled, managing census, helping patients use equipment, discharge, and follow up with primary care physicians and/or enrollment with Medicaid or one of our discount programs.

When they were assigned to VHH, most staff were fully dedicated (they did not have inpatient or clinic responsibilities). On low VHH census days, clinic-based RNs could flex back to their roles in their clinics to optimize hours. In terms of matching number of providers to patients, the ratio typically matched our outpatient productivity goals (1 provider to 10 patients). Similarly, with our nurses, we would have one nurse outreach to up to 10 patients per day, but as we became busier, we used a charge RN who helped lead the team, ensuring transfers to the ED and direct admissions were carried out.

We carried out very few in-home visits, mainly to protect staff and to conserve PPE. When it was necessary, we did have the opportunity flex our tuberculosis home-based program and sent them to high-risk/struggling patients at home.

The VHH program is based exclusively on telephone/telehealth visits but tried to reach the highest number of patients possible—used the telephone. If a patient was not responsive, we would call them at least three separate times in the morning, leaving several minutes between calls. If we reviewed our notes and knew those patients were doing relatively well, we assumed they were resting, and we reached back out in the afternoon as scheduled. If they were not doing well, we discussed whether we needed to reach out to the patient's emergency contacts. Our last resort was to ask local police or EMS to conduct welfare checks; this was done very rarely.

Overall, as of November 2020, the mean age of the 668 patients who participated in the VHH program was 51; almost 21% of patients were 65 or older. Nearly 60% of our patients were female, and most had primary care physicians prior to participating in the program. The majority of participants identified as Hispanic with slightly more than half listing English as their preferred language (Table 2) (we did have interpreters for patients who did not speak English). Most patients were referred by their primary care providers, followed closely by urgent care and the emergency department. The two most common risk factors patients had were hypertension and obesity (in some cases, patients had both), followed closely by COPD/asthma.

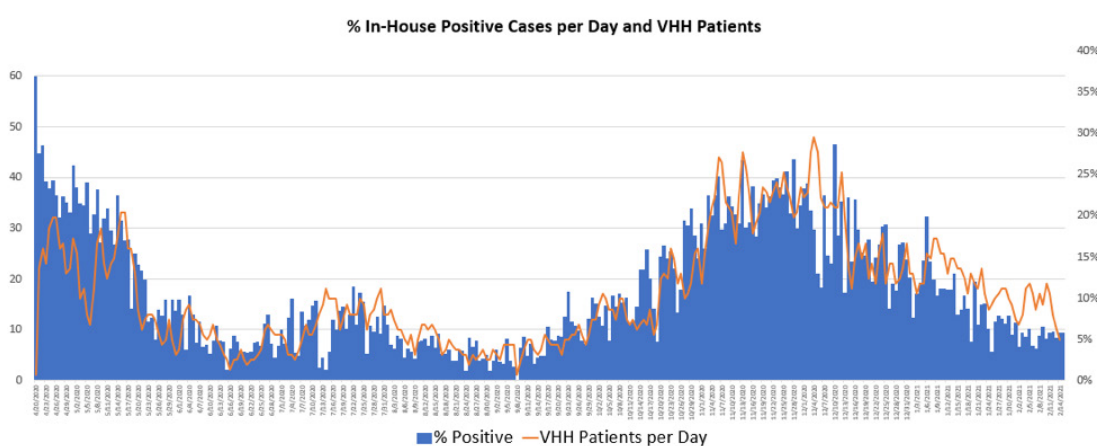
Table 2. VHH Patient Demographics as of November 25, 2020

Demographics	N = 668 (%)
Mean Age (std dev)	51.4 (15.4)
Age > 65	137 (20.5)
Female	391 (58.5)
Has a PCP	573 (85.8)
Race/Ethnicity	
Hispanic	460 (68.9)
White	122 (18.3)
African American	55 (8.2)
Other/Unknown	31 (4.6)
Preferred Language	
English	360 (53.9)
Spanish	283 (42.4)
Non-English/Non-Spanish	25 (3.7)
Referral Sources	
PCP	223 (33.4)
Urgent Care	187 (27.9)
Emergency Department	157 (23.5)
Post-Discharge	95 (14.2)
Other	6 (1)
Comorbid Conditions	
Hypertension	290 (43.4)
Obese Body Mass Index	288 (43.1)
COPD/Asthma	227 (34)
Chronic Artery Disease	29 (4)
Congestive Heart Failure	17 (2.5)

In May, 2020, we manually examined charts for outcomes of 233 patients and found that the vast majority (202, 87%) were discharged from the program, while 31 patients (slightly over 13%) either visited the emergency department or were admitted to the hospital.

Figure 5 illustrates the relationship between the percent of in-house positive cases and number of VHH patients per day from April 12, 2020 to February 14, 2021. While these numbers varied significantly on a daily and weekly basis, they did correlate closely together.

Figure 5. Percent In-House Positive Cases per Day and VHH Patients



We received overwhelming positive feedback from our patients and their loved ones. We found that many of our patients had anxiety about the prognosis and the loneliness they felt when they isolated themselves from their loved ones. Overall, patients and family members said the program ran smoothly and it helped them feel safe and reassured.

One of the biggest things we learned was the value of teamwork; as we mentioned earlier, this program was developed by an interdepartmental team. Having all those people at the table early on helped us develop a solid framework that enabled us to carry this model forward throughout the pandemic. We were all completely remote; we were working in our respective clinics or from our homes. The team really optimized the use of the EHR program and maintained clear lines of communication.

We also had to be quite flexible; the numbers of patients in hospital and VHH varied substantially, so we had to be nimble in flexing our staffing over time. This did put some strain on us; any time we pulled primary care providers to work in the program, we were pulling them from their practices, so we had to constantly shift staffing needs to the number of patients we had.

Finally, we had to be adaptable. We had so many new emerging treatments and strategies and we had to adapt our patient care in real time. Over the summer of 2020 (when we had fewer hospitalized patients) we were more likely to send patients into hospital to receive remdesivir. As we learned more about the virus and our own comfort levels increased, this shifted and we became more likely to treat them at home with oxygen and dexamethasone.

Now we have access to monoclonal antibody therapies and through Colorado's random allocating system (to ensure equitable distribution), we were able to enroll our patients into that system in conjunction with one of our urgent care clinics, sometimes on the same or next day. Because our numbers have declined so significantly, we recently shut down the VHH program (in early March 2021).

In the event of a subsequent surge, we would be ready to reimplement the VHH program seamlessly. There is also great opportunity to flex this program into the care of non-COVID conditions, such as COPD exacerbation, community-acquired pneumonia, and heart failure. Since the pandemic, there is more enthusiasm to use these types of virtual programs to keep patients at home and minimize their risk from acquiring hospital-based infections.

Patient Feedback

"The care team had communication with me, and they explained and answered all my questions. It was a good program because they were concerned about my health. I'm glad it will help others."

"I just want to tell everybody thank you, it (the pandemic) has been tough for a lot of people. My mom had a difficult time with her symptoms, but the doctors were there to help me care of my mom. The program was really good."