

Advancing a virtual home hospital: a blueprint for development and expansion

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ABSTRACT

Background The rising demand for hospitals has spurred increased interest in adopting virtual home hospital (VHH) care models. Development in this area often uses rigid research methods. This study describes a dynamic approach to constructing a VHH and outlines the progress over 5 years.

Methods In 2018, a multicentre VHH was developed in Edmonton, Alberta, Canada, using an innovation lab approach, fostering collaboration among healthcare stakeholders for design, prototyping and testing. Over a 5-year period (2018–2022), the VHH underwent trial and adaptation using the Model for Improvement and the Dynamic Sustainability Framework, refining integrated care for a broader patient population. Within the VHH, patients received acute, hospital-level care at home, using technology, existing services and hospital and community personnel. Outcome measures included number of patient cohorts, staffing numbers, patients served, capacity and hospitals/health centres supported.

Results Over 5 years, the VHH expanded from 2 to 15 staff members, from 14 to 25 physicians, from 45 to 870 total patients served, from 10- to 75-patient capacity and from serving 1 hospital to 6 hospitals and 1 health centre. The VHH advanced by transitioning from telehealth to digital remote patient monitoring, involving additional community partners, extending operating hours, diversifying admission and referral pathways and improving patient monitoring.

Conclusion A VHH has the potential to bridge the gap between hospital and community care and to become a permanent healthcare delivery model that supports continuity of patient care.

INTRODUCTION

In Alberta, Canada, approximately 5% of patients account for greater than 50% of hospital expenditures and acute care days.^{1,2} This small group of high-users (HU), often with complex chronic conditions and multiple comorbidities, disproportionately use a significant share of healthcare resources.^{1,3–5} The healthcare system is challenged by the growing elderly population and rising burden of chronic disease.⁶ Research indicates higher rates of inpatient readmissions, length of stay (LOS) and emergency

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Virtual home hospital (VHH) models provide hospital-level care at home, addressing the rising strain on the healthcare system from chronic disease and ageing populations. These models can reduce hospital admissions, length of stay, emergency department visits and costs while enhancing patient satisfaction and accessibility.

WHAT THIS STUDY ADDS

⇒ This manuscript reviews the development of a VHH using a quality improvement approach via a collaborative innovation lab. Unlike traditional models developed through rigid research methods, such as randomised controlled trials, this approach allowed for continuous adaptation to local needs.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This review of the VHH model serves as a guide for developing a care delivery system that bridges the gap between hospital and community care, offering an adaptable approach to reduce healthcare strains tailored to the local context.

department (ED) visits when patients are readmitted to a hospital different from the initial admission location, disrupting care continuity.^{7,8} Approximately half of readmissions could be prevented,⁹ demonstrating the potential for interventions targeting HU to provide hospital care for more patients.

Home hospital (HH) models offer the potential to reduce hospital admissions, LOS and ED visits, lowering costs and releasing resources for other patients.^{10–14} Virtual home hospital (VHH) models deliver hospital-level care to patients with acute illnesses or chronic conditions safely managed at home, using a combination of remote and in-person care facilitated by digital technology. Eligible patients are typically discharged from inpatient hospital care to the VHH or admitted directly from the ED or their general practitioner (GP), avoiding a hospital stay. Additional benefits of VHHs include enhanced



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patient satisfaction, reduced exposure to hospital-acquired infections, increased accessibility for rural patients and improved care transitions between hospital and community healthcare providers.^{12 13 15} Originating in England in 2006,¹⁶ VHH models have expanded globally,^{13 14 17–19} including in Canada where trials and evaluations are underway in Calgary, Victoria, Toronto and Montreal.^{19–22}

Previous studies used randomised controlled trials (RCTs) or similar methods to develop, implement and evaluate VHH models.^{11 13 14 17 23–26} Herein, we share the Alberta Health Services Edmonton Zone Virtual Home Hospital (EZVHH) model, which used a dynamic and collaborative innovation lab quality improvement (QI) approach. This approach fostered widespread collaboration among several hospitals and community partners across the healthcare system and facilitated continuous adaptation of the model to the specific needs of the local context. Developed in April 2018, the EZVHH aimed to enhance patient-centred collaborative care continuity between hospital and home. We present an overview of the model's development and outline the progress achieved over a span of 5 years, from 2018 to 2022.

METHODS

Setting, patient selection and ethics

The EZVHH was developed and initially trialled at a 728-bed quaternary teaching hospital in Edmonton, Alberta, Canada, between 2018 and 2019.²⁷ The impetus for the VHH was twofold: (1) an adverse event involving a young adult patient who unfortunately succumbed to a rare, complicated disease after multiple hospitals and ED admissions and (2) limited hospital capacity. The incident underscored the need for improved support and care continuity, prompting a call for action for an innovative and cost-effective model of care to address capacity pressures and enhance care for patients at risk of 'falling through the cracks' of the healthcare system. In response, a retrospective chart review identified and characterised HU for this hospital, revealing areas for improvement in serving this patient population.²⁸ One improvement opportunity was the VHH. Formal ethical committee approval was not required for the review of the EZVHH model.^{29 30}

Development, trial and expansion

Innovation lab for collaborative partner engagement and EZVHH model development

The EZVHH was developed using an innovation lab approach incorporating design thinking, facilitating cocreation, continuous learning and iterative change.^{31–35} This approach brought together various stakeholders in the healthcare system to collaborate creatively to define, ideate, prototype and test concepts.^{31–35} Participants included medical and operational hospital leaders, along with leaders from community care, home care, Health Systems Knowledge and Evaluation team, the hospital

technology department, emergency medical services (EMS) and Mobile Integrated Health (MIH) community paramedic programme (a provincially funded programme providing point of care testing and acute services in the patient's home within 2 hours of receiving a referral), forming the EZVHH development team. Their initial focus was to identify and leverage resources of existing acute and community-based services/programmes and personnel while incorporating new evidence from an extensive literature review to effectively support the initial model's design and development.

Model development

In 2018, the EZVHH patient cohort included HU, such as chronic obstructive pulmonary disease and heart failure (HF) patients. Admission requirements (inclusion criteria) were adult patients (18 or older), with three or more admissions to any acute care facility within the Edmonton Zone in the previous 365 days, receiving a referral to the EZVHH from a physician or healthcare team and having a LACE score (Length of stay, Acuity of admission, Comorbidities and ED visits; a tool designed to predict hospital readmissions) that equalled or exceeded 10.³⁶ The model was funded by the local health organisation for 1 year and operated from 08:00 to 16:00 on weekdays, with after-hours care provided by an on-call registered nurse (RN). EZVHH personnel, called the integrated complex care team (ICCT), included 1 RN, 14 rotating general internal medicine (GIM) physicians and a pharmacist, collaborating closely with pre-existing home care, primary care and community-based services, including radiology and laboratory services, palliative care, EMS and MIH. Engagement with primary care and community-based services was essential in codesigning and further developing the final model, ensuring effective coordination and continuity of care.

The ICCT rounded daily in-person to discuss new patients, review care plans and follow up with patients through telephone discussions. GPs were invited to join rounds via telephone, and patients without a GP were assisted in finding a physician. Patients were referred to the EZVHH and discharged from inpatient hospital units by GIM and pulmonary physicians. Patients received individually tailored interventions, including enhanced discharge planning and coaching for chronic disease self-management using standardised action plans and individualised care plans prior to discharge from the acute hospital to the EZVHH. These care plans included written discharge instructions, including who to call when their condition changes, appointment schedules and medication changes. The EZVHH pharmacist coordinated medications with specialists and community pharmacists to reduce medication errors. Patient monitoring involved telephone reviews within 24 hours, home assessments by home care and/or EMS and regular telephone reviews to identify early complications.

Model trial

The initial EZVHH was trialled using the Model for Improvement.³⁷ This QI approach involves Plan, Do, Study, Act (PDSA) iterative cycles, which facilitate continuous learning and modification for improvement.³⁷ During the trial phase, three PDSA cycles were conducted over 1 year (2018–2019) at one teaching hospital. Ongoing

stakeholder meetings were conducted in the innovation lab to refine the model by addressing challenges, developing strategies to enable the VHH model and integrating local insights and emerging evidence (table 1). The first PDSA cycle, in April 2018, trialled initial action plans and protocols with two patients. The EZVHH nurse and GIM physician visited GIM and pulmonary hospital

Table 1 Challenges and strategies used to enable the virtual home hospital (VHH)

Identified challenge	Enabling strategy
1. Competing priorities of community, hospital, health organisation and physician leaders, in addition to unfamiliarity of community- and hospital-funded programmes and staff	Formed a <i>VHH development team</i> to establish joint priorities and to understand resource availability.
2. Limited funding (initial 1-year funding)	Developmental team members <i>identified existing funded resources</i> (programme and personnel) within acute and community-based services/programmes to limit expenditure.
3. Need for sustained funding for model continuation and expansion	Secured permanent <i>organisational funding</i> through the completion of rigorous evaluation that included organisational (hospital and community) metrics, patient and staff satisfaction. Evaluation reports were provided to senior health organisational leaders.
4. Increased patient needs outside of regular operating hours (Monday–Friday 8:00–16:00), with limited on-call staff	<i>Expanded VHH operating hours</i> to Monday–Sunday 08:00–16:00. After-hours support was provided by emergency medical services (EMS) or Health Link (a community-based programme that is a call centre staffed with nurses to provide medical assistance).
5. Limited community programmes/resources to provide home-based treatments (eg, intravenous medications) preventing emergency department (ED) or hospital admission	Collaboration with the <i>Mobile Integrated Health community paramedic programme</i> .
6. Lack of standard physician recruitment, mentorship and scheduling	Developed a <i>physician VHH recruitment process and mentoring process, as well as a schedule</i> . Physicians who worked in the VHH served as mentors providing guidance to newly onboarded physicians and a resident rotation was established.
7. Lack of hospital electronic medical record (EMR) process for VHH admission and virtual bed assignment	An <i>EMR VHH pathway</i> was established to support electronic patient admission and virtual bed assignment.
8. Limited technology to support remote patient care	Obtained <i>digital remote patient monitoring technology kits</i> : smart blood pressure and heart rate monitoring with wrist cuff, smart weigh scale, smart oximeter (saturation monitor), thermometer and Bluetooth-enabled tablet with Zoom video conferencing technology.
9. Lack of VHH staff (unit clerk, nurse and pharmacist) training documents	Developed <i>standard operating guidelines</i> which were reviewed and updated annually.
10. Lack of interdisciplinary virtual rounds to coordinate care between hospital and community staff	Developed an <i>integrated complex care team (ICCT)</i> , which included 1 RN, 14 rotating general internal medicine (GIM) physicians, a pharmacist, home care, primary care and community-based services, including radiology and laboratory services, palliative care, EMS and MIH. Telephone rounds occurred daily between the ICCT and patients.
11. Patients without a community physician	A <i>community physician was identified and provided</i> for all patients without a physician, ensuring community physician–patient support and involvement in the ICCT daily rounds.
12. Lack of patient awareness regarding the transition from hospital to VHH care	Developed <i>patient hospital discharge and VHH transfer instructions</i> . Patients were contacted prior to hospital discharge to acknowledge VHH involvement in their continued care at home.
13. Medication management to prevent complications (ie, emergency visits, medication errors)	<i>VHH pharmacist</i> conducted a thorough medication review, liaised with the community physician and pharmacy and provided patient medication education prior to hospital discharge and prior to/during VHH admission.
14. Patient deterioration in the community	Initially, the <i>Unexpected Deterioration in the Community process</i> was developed. This care pathway allowed VHH patients to access the hospital in a non-ED space to be seen by the VHH nurse and physician. This was replaced by the <i>Mobile Integrated Health community paramedic programme</i> to prevent emergency and hospital visits.
15. Limited physician ability to admit patients directly to VHH	Established that <i>ED and community physicians</i> can directly admit to VHH, preventing ED visits and hospital admissions.
16. Limited awareness of the VHH programme among community physicians	VHH programme information was communicated through the <i>health organisation's website and the provincial referral directory</i> (a repository of referral programmes with requirements). The local primary care network and a <i>VHH introduction letter</i> informed community physicians of patient enrolment and provided programme awareness.

Table 2 Edmonton Zone Virtual Home Hospital (EZVHH) model components comparison

Model	Year 1 (2018)	Year 5 (2022)
Inputs		
Funding	Pilot organisation funding	Permanent organisation funding
Patient cohorts	Chronic obstructive pulmonary disease (COPD) and heart failure (HF)	Medicine: general internal medicine (GIM), pulmonary (COPD), cardiology (HF) Surgery: general surgery, obstetrics and gynaecology
Hours of operation	Monday–Friday 08:00–16:00 Pager access for urgent calls	Monday–Sunday 08:00–20:00 After-hours call emergency medical services (EMS) or Health Link
Staffing	1 Registered nurse, 1 pharmacist and 14 GIM physicians	10 Registered nurses (6 medical, 4 surgical), 1 programme manager, 1 nurse practitioner, 2 pharmacists (1 full-time, 1 part-time) and 1 unit clerk 25 Physicians: 14 GIM, 1 anaesthesiology, 2 general surgery, 2 cardiology, 1 transplant surgery, 5 obstetrics and gynaecology
Community partners	General practitioner (GP), EMS, home care, palliative care, laboratory services	Mobile Integrated Health (MIH) within EMS, GP, home care, palliative care, laboratory services and courier service (to deliver digital remote patient monitoring technology)
Process		
Technology	Telehealth	Digital remote patient monitoring technology kits: smart blood pressure and heart rate monitoring with wrist cuff, smart weigh scale, smart oximeter (saturation monitor), thermometer and Bluetooth-enabled tablet with Zoom video conferencing technology
Admission/referral pathways	1. Patients are discharged from inpatient hospital ward to VHH (hospital-based physician refers to EZVHH) 2. Patients are admitted directly, from the unexpected Deterioration in the Community Process (EZVHH physician refers to VHH)	1. Patients are discharged from inpatient hospital ward to VHH (hospital-based physician refers to EZVHH) 2. Patients are admitted directly from ED, avoiding inpatient admission (ED physician refers to EZVHH) 3. Patients are admitted directly by GP, avoiding inpatient admission (GP physician refers to EZVHH)
Patient care plans	Standardised action plans, individualised care plans and enhanced discharge plans	
Patient monitoring	1. Phone review within 24 hours of hospital discharge 2. Regular phone reviews until discharge 3. Home assessments by home care/EMS	1. Intake call prior to inpatient hospital discharge or immediately after ED/GP referral acceptance 2. Daily telephone call for first 3 days 3. Regular phone reviews until discharge 4. Home assessments by MIH
Interdisciplinary team daily patient rounds	In-person, followed by telephone discussion with patient and caregiver	Virtual, includes patient and caregiver as well as the GP
Outputs		
Cumulative number of unique patients served to date	45 (March 2019)	870 (March 2022)
Patient capacity	10 (medicine)	75 (45 medicine, 30 surgery)
Number of hospitals/health centres supported	1 hospital	6 hospitals and 1 health centre
ED, emergency department; VHH, virtual home hospital.		

units in-person to identify eligible patients at high risk of readmission. In this cycle, modifications were made to streamline referral processes and inclusion criteria. The second cycle, starting in July 2018 with 10 patients, refined admitting, care and discharge processes, introducing the ‘Unexpected Deterioration in the Community’ process. This care pathway allowed EZVHH patients to access the hospital in a non-ED space to be seen by the EZVHH nurse and physician. During the third cycle in spring 2019, involving 33 patients, MIH replaced the ‘Unexpected Deterioration in the Community’ process, enabling community paramedics to assess and care for patients at home, circumventing the need for hospital visits in many cases. Additionally, staff roles were formalised, internal processes further refined, and a hospital

electronic medical record (EMR) method for admitting patients to a virtual hospital unit was implemented. By March 2019, the EZVHH had served 45 unique patients and had capacity for 10 medicine patients, supporting one hospital (table 2). In early 2020, continuous stakeholder engagement in the innovation lab supported the suitability of the EZVHH for gradual expansion across the Edmonton health zone to other hospitals and for additional patient cohorts beyond HU, including surgical and obstetrics and gynaecology patients.

Model adaptation and expansion

The Dynamic Sustainability Framework guided the expansion and adaptation of the EZVHH, emphasising healthcare solution sustainability through continuous

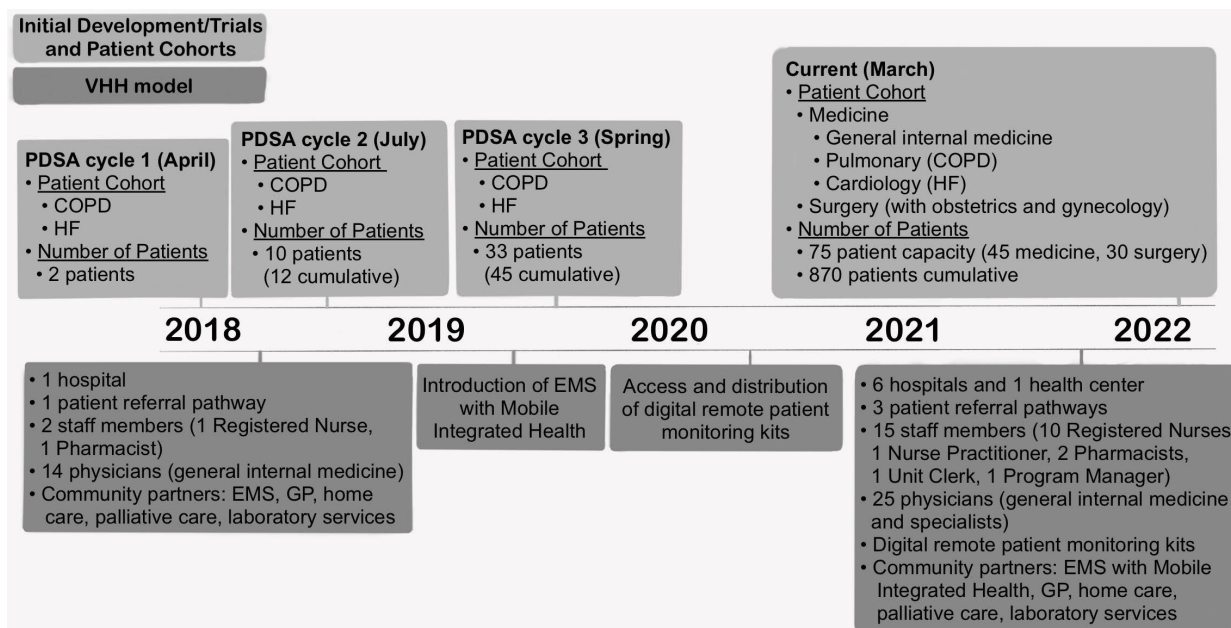


Figure 1 Timeline of Virtual Home Hospital Development and Advancement. This timeline illustrates the continuous advancement of the Virtual Home Hospital model using Plan-Do-Study-Act (PDSA) cycles from 2018 to 2022. The top row indicates the gradual growth in patient cohorts and capacity, as well as the number of patients served by the model. The bottom row outlines the number of hospitals, referral pathways, staff, partners and the introduction of technology. COPD, chronic obstructive pulmonary disease; dRPM, digital remote patient monitoring; EMS, emergency medical services; GP, general practitioner; HF, heart failure; VHH, virtual home hospital.

learning (via PDSA cycles), problem-solving and ongoing adaptation within the local context.³⁸ The EZVHH model underwent continuous improvement by involving relevant stakeholders, partners and personnel within an innovation lab to refine and adapt previously developed disease-specific integrated care to meet the needs of a larger patient population within the local context, using PDSA cycles for ongoing iterative improvement. Patient cohorts, hospitals and health centres were gradually added over 5 years (2018–2022).

RESULTS

Over 5 years, EZVHH patient cohorts were expanded to include GIM, pulmonary, cardiology and surgical patients, including obstetrics and gynaecology patients (figure 1). Admission (inclusion) criteria (figure 2) for medicine patients included adult patients capable of providing consent, functionally independent (or with caregiver support), at risk for future ED visits or acute care readmissions, and in need of hospital-level care that could be administered at home or in one to two visits per day by MIH. Patients or their caregivers were required to communicate by phone or computer and follow treatment instructions with support. Patients needed to reside (or would receive care) in Alberta, either within 50 km of the Edmonton metro area for full EZVHH services or within Alberta if they requested digital remote patient monitoring (dRPM). The dRPM kits included a thermometer, weigh scale, oximeter, blood pressure (BP)/heart rate monitor and a Bluetooth-enabled tablet with

Zoom video conferencing technology to enhance remote monitoring by VHH healthcare providers. Patients were excluded if they were on continuous cardiac monitoring, required intravenous therapy more than two times per day, did not qualify or could not pay for home oxygen, or did not have a safe place to receive care. These criteria (figure 2) also applied to surgical patients who required preoperative or postoperative general surgery support.

Inclusion criteria for obstetrics and gynaecology (figure 2) patients consisted of being a postpartum patient who is obstetrically stable and (1) diagnosed with hypertension, gestational hypertension or HELPP spectrum disorders during pregnancy, labour or postpartum, (2) required daily BP monitoring and medication adjustments and (3) resided in the Edmonton zone (within 50 km of the Edmonton metro area). Patients also needed to be capable of providing consent for care from the VHH, communicate with the provider (either directly, through a family member or via a language line), have a working telephone at home and be able to manage virtual care technology, be able and willing to follow their care plan and ensure a safe environment for potential MIH visits. Exclusion criteria included (1) any instability, including risk of complications (eg, haemorrhage, sepsis, arrhythmia), unstable BP or complex hypertension (systolic BP >170 and/or diastolic BP >120, or symptomatic with new or worsening headache, malaise, epigastric/chest pain, visual disturbances or shortness of breath), or worsening symptoms like persistent epigastric/chest pain, oliguria or low oxygen saturation requiring supplemental

2018	2022	
COPD and HF	Medicine and Surgery	Obstetrics and Gynecology
Inclusion • Age 18+ • 3+ admissions to acute care facilities in Edmonton Zone in the last year • Referred by physician or healthcare team • LACE score ≥ 10	Inclusion • Able to provide consent • Functionally independent (or supported by caregiver) • At risk of future ED visits or acute care admissions • Requires hospital-level care that can be administered at home • Able to communicate via phone/computer • Able to follow treatment instructions • Resides (or receives care) in Edmonton Zone (for full services) or within Alberta (with dRPM kits)	Inclusion • Stable postpartum patient • Diagnosed with hypertension, gestational hypertension, or HELPP during pregnancy or peri-/post-partum • Requires daily BP monitoring • Resides in Edmonton Zone • Can provide consent for care • Able to communicate with provider (directly or through a translator) • Has telephone and can manage virtual care technology • Can adhere to care plan
	Exclusion • Requires continuous cardiac monitoring • Requires IV therapy $>2x/day$ • Unable to obtain home oxygen • Lacks safe environment for care	Exclusion • Patient instability • Current or recent (within 24 hr) $MgSO_4$ treatment • Needs medication administered $>2x/day$ • Lacks safe environment for care

Figure 2 Inclusion and exclusion criteria for Edmonton Zone Virtual Home Hospital (EZVHH) patients in 2018 compared with 2022. The figure depicts inclusion criteria for COPD and HF patients for admission to the EZVHH in 2018, and inclusion/exclusion criteria for medicine surgery, and obstetrics and gynaecology patients for admission in 2022. BP, blood pressure; COPD, chronic obstructive pulmonary disease; dRPM, digital remote patient monitoring; ED, emergency department; HELPP, hemolysis, elevated liver enzymes, and low platelet count; HF, heart failure; IV, intravenous; LACE, Length of stay, Acuity of admission, Comorbidities and ED visits.

oxygen, (2) current or recent treatment with $MgSO_4$ treatment (<24 hours since discontinuation) and (3) the need for medication administration more than two times per day.

The EZVHH secured permanent organisation funding in early 2020 (figure 1). Operational hours were expanded, Monday to Sunday from 08:00 to 20:00, with patients directed to call EMS for urgent concerns or the local Health Link for non-urgent issues after-hours. EZVHH staff reviewed after-hours voicemails, emails and vital signs on the subsequent day. The ICCT grew to include 10 RNs (6 medical, 4 surgical), 1 programme manager, 1 nurse practitioner, 2 pharmacists (1 full-time and 1 part-time), 1 unit clerk and 25 physicians (14 GIM, 1 anaesthesiology, 2 general surgery, 2 cardiology, 1 transplant surgery, 5 obstetrics and gynaecology). The model incorporated an expanded range of stakeholders, including a courier service for delivering dRPM technology kits to patients' homes, and MIH, a specialised EMS service offering intravenous medication administration and home assessments.

Additional patient admission pathways were introduced, allowing direct referrals, either from the ED by an ED physician, or from the community by a GP, avoiding an inpatient hospital stay. Patient care continued to be supported by standardised action plans, individualised care plans and enhanced discharge plans. Communication was improved with patients contacted before

inpatient hospital discharge or immediately following an accepted ED/GP referral, followed by daily telephone calls for the first 3 days and subsequent regular follow-up calls. Home assessments were conducted by home care or MIH. The inclusion of dRPM kits facilitated virtual interdisciplinary rounds involving the patient, caregiver and GP. Patients without a GP received support to locate one. By March 2022, the EZVHH had served 870 unique patients with an expanded capacity for 75 patients (45 medicine and 30 surgery) supporting six hospitals and one health centre. Throughout the expansion and adaptation, the ICCT's roles, responsibilities and foundational operational processes remained unchanged (figure 3; table 2).

DISCUSSION

Over 5 years (2018–2022), the innovation lab approach successfully fostered collaboration between hospital and community healthcare partners codesigning VHH. Initially, challenges arose in uniting community and hospital stakeholders due to their unfamiliarity with such comprehensive care integration and discrepancies in funding and service operations within the local health system.¹⁹ Despite these challenges, the innovation lab environment fostered uninhibited creative collaboration, leading to cocreation of the initial EZVHH. The iterative QI approach using PDSA cycles allowed for continuous

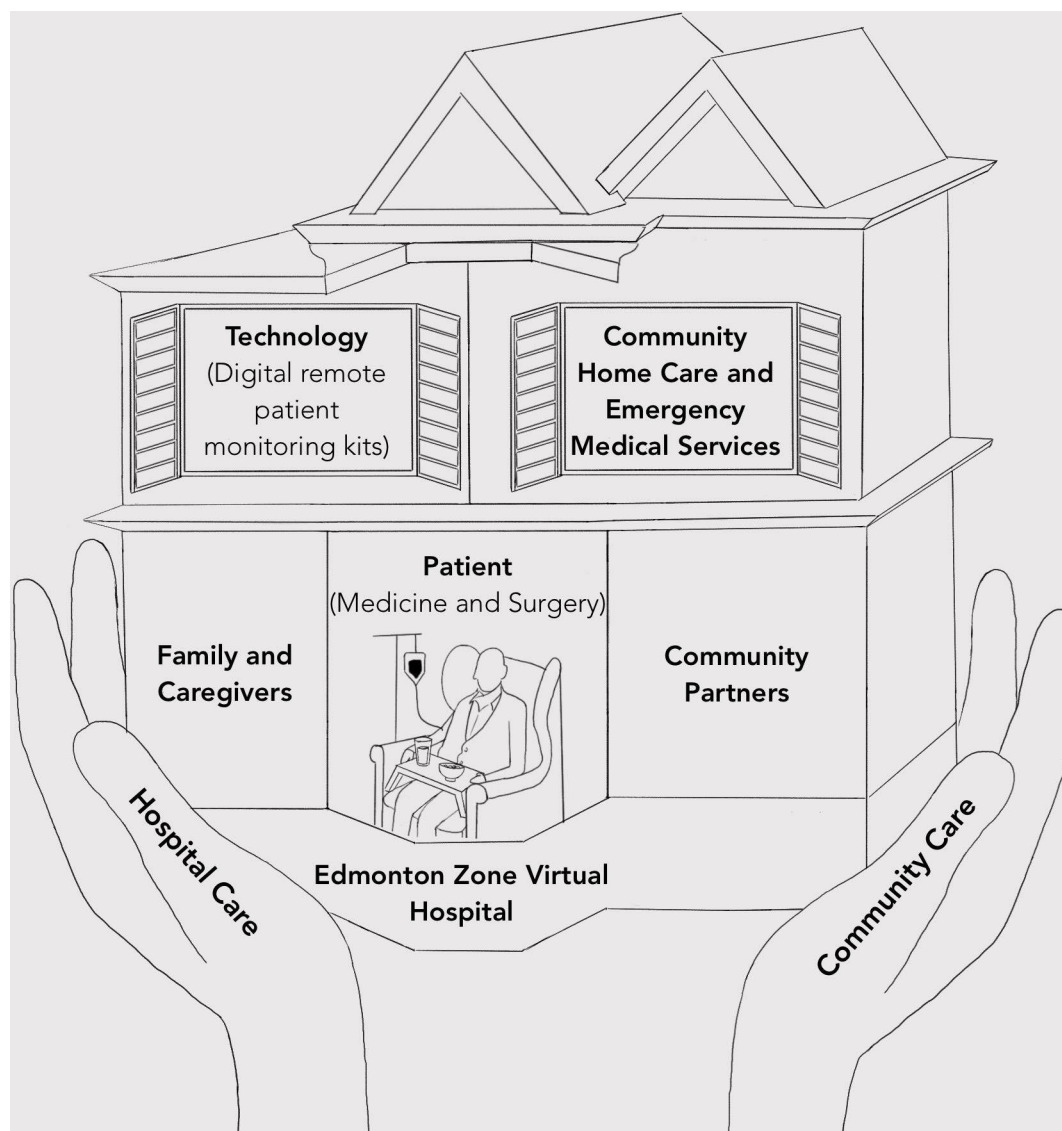


Figure 3 Blueprint of the Edmonton Zone Virtual Home Hospital (EZVHH). The depicted figure illustrates the foundational elements of the EZVHH. At its core is the patient (encompassing both medical and surgical patient cohorts), around whom the model is built. Patient care is supported by a combination of components, including digital remote patient monitoring technology, involvement of family and caregivers, engagement of community home care and emergency medical services, and collaboration with community partners. The EZVHH serves as the foundational bridge between hospital and community care.

learning and adaptability, contrasting with rigid methods (RCTs) in previous VHH studies.^{11 13 14 17 23–26} EZVHH's advancement required additional adaptation, including changes based on local hospitals (from one to six hospitals and one health centre), healthcare partners, specific patient cohorts (eg, medicine subspecialty and surgery patients) and the COVID-19 pandemic response. Leveraging pre-existing funded healthcare resources and personnel (eg, MIH and home care) may contribute to EZVHH's cost-effectiveness, while other VHHs have faced challenges in funding conceptualisation.^{23 39}

Anticipated benefits of the VHH include improved patient outcomes, enhanced experiences for patients, caregivers and healthcare providers, as well as reduced healthcare costs and resource utilisation.^{12 13 15} These benefits encompass decreased ED visits, fewer readmissions

to acute care—especially among individuals at high risk for readmission—and shortened LOS in acute care settings.^{10–14} However, due to the need for adaptation to local contexts,¹⁴ there is limited published evidence regarding comprehensive evaluation approaches for VHHs, resulting in varied impacts ranging from significant to negligible.^{12–14 23 40–45} A Toronto-based trial showed no reduction in readmission rates or mortality among high-risk patients who received postdischarge virtual ward care,²³ whereas Singapore successfully implemented a VHH reducing 30-day readmissions and ED visits in high-risk patients.¹⁴ The Singapore model, unlike Toronto, incorporated prehospital discharge transitional care and virtual home monitoring technology, similar to the standardised action plans, individualised care plans and dRPM kits used in the EZVHH, suggesting the

possibility of achieving comparable impact. Unlike RCTs conducted in Singapore and Toronto, the innovation lab and improvement approach provided greater flexibility for customising interventions and refining the model iteratively, enabling real-time optimisation of resources and incorporation of new evidence.

A systematic review on remote patient monitoring found approximately 77% of published studies reported positive clinical or economic impacts.⁴⁶ These benefits included improved patient safety, confidence, knowledge, self-management, early identification of clinical exacerbations and increased shared decision-making between patients and providers.⁴⁷ Remote patient monitoring was also found to reduce readmissions, LOS and ED presentations.^{47 48} Studies have compared the safety and efficacy of VHHs using referral pathways similar to the EZVHH model⁴⁹ and using a centralised command centre, resulting in positive outcomes (ie, low mortality rates and reduced hospital readmissions).⁵⁰

Further expansion of the EZVHH requires developing more partnerships with community organisations for social work and physical therapy (enabling earlier transition to VHH and access to rehabilitation), increasing patient capacity including paediatric populations and establishing a provincial VHH programme. Clinical recruitment, effective leadership and raising awareness among community GPs are also essential. Additionally, optimising communication between hospital and community healthcare providers through a single integrated EMR platform⁵¹ and improving after-hours care access⁵² by expanding operating hours or implementing on-call healthcare providers are necessary. Continuous evaluation is ongoing, focusing on patient, caregiver and provider experiences, alongside key parameters like readmission rates, LOS, ED visits, and costs compared with traditional inpatient care.

Limitations include that the key parameters, such as subjective patient/provider experiences and objective financial and efficiency measures, were not finalised and were still ongoing at the time of this review. Considering these parameters will allow for a more detailed assessment of the long-term sustainability of this VHH model. Challenges persist in defining suitable outcome measures, conducting rigorous comparisons and evaluating coordination among healthcare providers,^{14 19 53} especially given that the EZVHH has leveraged existing hospital and community structures and personnel with diverse funding approaches, IT platforms and data collection methods. Despite complexities, growing adoption of virtual technology underscores the importance of VHHs as a bridge between hospital and community care, especially given the impact of the COVID-19 pandemic on healthcare delivery patterns.^{54 55}

CONCLUSION

Leveraging innovation and improvement science frameworks facilitated the collaborative development of a VHH.

Ongoing efforts in data collection, statistical analysis and cost evaluation aim to facilitate continuous improvement and expansion across Alberta, informing the development of a provincial VHH model. VHHs have the potential to become a permanent healthcare delivery model, bridging the gap between hospital and community care while ensuring the continuity of patient care.

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Contributors PM led the manuscript approach and writing. IP co-led the manuscript writing. HD-F assisted with figure development. GH critically reviewed and edited the manuscript. NM critically reviewed and edited the manuscript. NK is the guarantor for this work and reviewed and approved the manuscript approach.

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Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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