

## Original Article

# Management of Frail and Older Homebound Patients With Heart Failure: A Contemporary Virtual Ambulatory Model

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### ABSTRACT

**Background:** Heart failure (HF) affects many patients who are older and frail, presenting multiple physical barriers to accessing specialty care in a traditional ambulatory clinic model. Here, we present an assisted virtual care model in which a home visiting nurse facilitated video visits with a HF cardiologist to follow homebound, frail, and older patients with HF.

**Methods:** This is a pragmatic, quasi-experimental, pre–post, single-centre study. It included homebound, frail, and older patients with HF from 2015 to 2019 who were followed for 1 year; in-person clinic visits were completely replaced by nurse-facilitated virtual video visits. Outcomes evaluated included annualized hospitalization rate, number of hospitalization days, and number of emergency department visits.

### RÉSUMÉ

**Contexte :** L'insuffisance cardiaque (IC) touche de nombreux patients âgés et fragiles, et dresse maints obstacles physiques à l'accès aux soins spécialisés au sein d'un modèle classique de soins cliniques ambulatoires. Dans le présent article, nous exposons un modèle de soins virtuels assistés où une infirmière visiteuse assure par vidéoconsultation, avec un cardiologue, le suivi de patients âgés et fragiles atteints d'IC confinés à la maison.

**Méthodologie :** Une étude monocentrique et pragmatique, quasi expérimentale de type « avant-après », a été menée de 2015 à 2019 auprès de patients âgés et fragiles atteints d'IC confinés à la maison. Les patients ont été suivis durant un an; les consultations en personne ont été entièrement remplacées par des vidéoconsultations effectuées

Heart failure (HF) is a common, progressive clinical syndrome, with a prevalence that increases with age; more than half of patients currently living with HF in North America are older than 70 years.<sup>1</sup> The disease is characterized by frequent exacerbations leading to recurrent emergency department (ED) visits and hospitalizations.<sup>2</sup> Ambulatory HF clinic visits have been instrumental in improving HF-related outcomes, including healthcare resource use.<sup>3,4</sup> Over the past decade, efforts to improve HF management have focused on various telemonitoring strategies that complement ambulatory clinics. These strategies have had mixed results in reducing HF

hospitalizations.<sup>4</sup> Unfortunately, HF clinics are relatively inaccessible to some of the highest-risk patients, owing to patient frailty and immobility; some patients with HF are simply too sick or cannot make the effort required to visit a clinic. The proportion of patients with HF who are unable or unwilling to physically interact with the medical system has only increased during the global coronavirus disease 2019 (COVID-19) pandemic.<sup>5-7</sup>

Virtual visits using videoconferencing technology are an appealing solution, but data to support their efficacy and safety in replacing in-person visits for this patient population remain limited. Legitimate concerns persist as to the reliability of the technology, the fidelity of the virtual interaction, and the willingness of an older patient population to accept these kinds of medical interactions.<sup>8</sup> Here, we describe the implementation and impact of an assisted virtual care model for older patients living with HF in Toronto, Canada. The model combines in-person geriatric clinical nurse specialist home visits with virtual specialist consultation via the Ontario Telemedicine Network (OTN), a provincially-funded

Received for publication August 10, 2021. Accepted August 27, 2021.

**Ethics Statement:** The project was approved by the Research Ethics Board at Sinai Health System, Toronto, Ontario, Canada.

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See page 55 for disclosure information.

**Results:** A total of 49 patients were included, with a median age of 86 (83-93) years, and were followed for 1 year after enrollment. Among patients enrolled, HF with preserved ejection fraction was the most common subtype (57%). Compared to the year prior to enrollment, patients had a lower mortality-adjusted all-cause annualized hospitalization rate in the year following enrollment (2.57 vs 1.78,  $P < 0.0001$ ). Compared to the year prior, the number of mortality-adjusted all-cause hospitalization days was significantly lower in the year following enrollment (27.2 vs 21.4,  $P < 0.0001$ ). There was a reduction in the number of all-cause annualized emergency department visits (3.10 vs 2.27,  $P = 0.003$ ).

**Conclusions:** Nurse-assisted virtual visits may be a preferable strategy for homebound, frail, and older patients with HF to receive longitudinal care. This approach may represent a plausible strategy to care for other patients with significant barriers to accessing specialized cardiac care.

videoconferencing service. We term these visits nurse-assisted virtual visits.

## Methods

### Study setting

The Ontario Health Toronto (OH Toronto) Region Urban Specialist Telemedicine Program for Homebound Elders is a model of care implemented by the Healthy Ageing and Geriatrics Program of Sinai Health System, a large academic urban health sciences centre located in Toronto. This outreach initiative leverages OTN videoconferencing technology and the support of a dedicated geriatric clinical nurse specialist to bridge the barriers in accessing secondary specialty care for homebound frail older persons living with complex and interrelated health and social care issues that require advanced longitudinal management. The project dispatches one advanced-care practice nurse specialist to coordinate real-time virtual visits between the homebound patient and their hospital-bound specialist. The project was approved by the Research Ethics Board at Sinai Health System. The project was funded by the Sinai Health Healthy Ageing and Geriatrics Program Research Fund.

### Study design and patient identification

We conducted a pragmatic, quasi-experimental pre-post cohort study that evaluated outcomes in a cohort of patients 1 year after their enrollment in the Urban Specialist Telemedicine Program for Homebound Elders from fiscal years 2015 to 2019. Outcomes prior to enrollment were retrospectively collected using patient medical records. Enrollment concluded prior to the onset of the current global COVID-19 pandemic. Patients meeting the following criteria were eligible for the study: (i) age 65 years or older; (ii) deemed to be

par une infirmière. Les paramètres évalués comprenaient le taux annualisé d'hospitalisation, le nombre de jours d'hospitalisation et le nombre de consultations aux urgences.

**Résultats :** Au total, 49 patients dont l'âge médian était de 86 ans (83-93 ans) ont été suivis durant un an à compter de leur admission à l'étude. L'IC à fraction d'éjection préservée était le sous-type d'IC le plus fréquent (57 %) chez les patients participant à l'étude. Par comparaison à l'année précédente, le taux annualisé d'hospitalisation toutes causes confondues ajusté en fonction de la mortalité a été plus faible chez les patients au cours de l'année où ils ont été suivis dans le cadre de l'étude (2,57 vs 1,78,  $P < 0,0001$ ). Toujours par comparaison à l'année précédente, le nombre de jours d'hospitalisation toutes causes confondues ajusté en fonction de la mortalité a été significativement inférieur chez les patients au cours de l'année où ils ont été suivis dans le cadre de l'étude (27,2 vs 21,4,  $P < 0,0001$ ). Le nombre annualisé de consultations aux urgences toutes causes confondues a quant à lui diminué (3,10 vs 2,27,  $P = 0,003$ ).

**Conclusions :** Les consultations virtuelles assistées par une infirmière peuvent constituer une stratégie à privilégier dans la prestation de soins longitudinaux à des patients âgés et fragiles atteints d'IC qui sont confinés à la maison. Cette approche pourrait représenter une stratégie plausible pour prodiguer des soins à d'autres patients qui sont confrontés à d'importants obstacles limitant leur accès à des soins spécialisés en cardiologie.

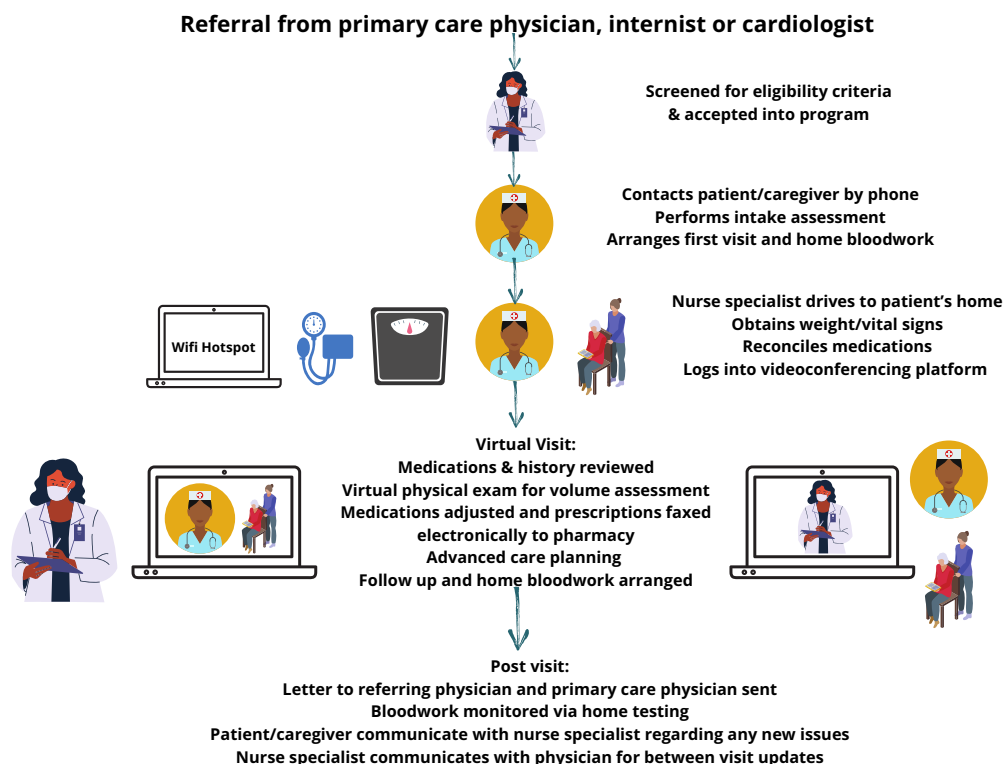
homebound by the referring clinician; (iii) reside in the OH Toronto region; and (iv) have a diagnosis of HF, regardless of subtype. Patients residing in long-term care or nursing homes were excluded. The eligible patients were consecutively identified and referred to the Urban Specialist Telemedicine Program for Homebound Elders by their care providers through broad referral pathways—(i) patients discharged home from a recent hospitalization were referred by their attending physicians; and (ii) ambulatory patients who would be better suited by this model of care were referred by local cardiologists or primary care providers.

### Patient intake and initial assessment

Referred patients and their caregivers were approached and provided with detailed information about the telemedicine program by its geriatric clinical nurse specialist upon patient enrollment. The clinical nurse specialist would conduct a medical records review, as well as a focused, comprehensive geriatric assessment during an initial home visit. A preliminary report was then sent to the cardiologist to be used to support an initial consultation. Home bloodwork was also arranged if no recent results were available for the patient (Fig. 1).

### Virtual consult and subsequent assessments

Nurse-assisted virtual visits were performed by an HF cardiologist with the assistance of the nurse specialist who would be present with the patient in their own home during the visit. Appointments would be booked in advance by the nurse specialist for times between Monday and Friday, 8 AM to 5 PM. The nurse specialist would drive to the patient's home with a scale, a sphygmomanometer, a laptop computer, and a wireless-network access point. Upon arrival, the nurse specialist would take a focused history and measure vital signs and weight. These data would be inputted directly into the



**Figure 1.** Cardiology virtual visit flow chart.

patient's electronic medical record (EMR). Next, both the nurse specialist and the cardiologist would log into the videoconferencing platform. The cardiologist would then review the patient's clinical status, perform medication reconciliation, review vital signs and weight, examine the patient's internal jugular venous pressure (JVP) and evaluate for the presence of peripheral edema, and review recent bloodwork. In order to assess the JVP, the nurse specialist would optimize lighting and patient positioning. Generally, the patient was evaluated while sitting up. The JVP would be categorized as either obviously elevated, obviously not elevated, or not well seen. Occasionally, the nurse specialist would offer confirmation of the assessment. Finally, the cardiologist and patient and/or caregiver would engage in HF education and advanced care planning. Virtual interaction with the cardiologist lasted approximately 10-30 minutes. The nurse typically spent 1 hour at the patient's home, visiting 1-3 patients per day and approximately 6 patients per week. Virtual visits did not take place every day; outside of participating in the visits and traveling to the visits, the nurse specialist was also involved in preparing assessments, communicating with patients and caregivers, and helping to coordinate treatments plans from prior visits.

### Post-virtual consult or subsequent assessment

After the initial nurse-assisted virtual visit or subsequent assessment, the plan of care was discussed with the patient and her/his family and the clinical nurse specialist, and communicated to the patient's primary care providers via a letter. Follow-up time intervals were determined by the cardiologist. Medication change requests were faxed from the EMR to the patient's pharmacy. Home bloodwork was arranged through a

local lab, and results automatically populated the patient's EMR. An updated nursing report was prepared by the clinical nurse specialist before subsequent virtual assessments.

### Data collection and outcome measurements

Data were obtained from patient charts and EMRs. The following endpoints were analyzed: (i) hospital utilization (all-cause hospitalization, cardiovascular-associated hospitalization, ED visits, all-cause hospital days, and cardiovascular-associated hospital days; and (ii) medication adjustment. The total daily doses for loop and thiazide diuretics were calculated, converting to equivalents for furosemide and metolazone, ([Supplemental Table S1](#)). **Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC)** risk scores were calculated using an online calculator.<sup>9</sup> Mortality data were collected so that outcomes could be adjusted as standardized annualized rates to account for mortality. Outcomes from 1 year before and 1 year after enrollment were compared.

### Statistical analysis

Descriptive statistics were used to summarize demographic characteristics, clinical characteristics, vital signs, laboratory results, medication use prevalence, and diuretics titration results. The results were described using mean, median, standard deviation, percentage, and range (25th-75th percentile), as appropriate. The Shapiro-Wilk test was used to assess whether a normal distribution was present. The Wilcoxon signed-rank test was used for skewed data. *P* values < 0.05 were considered statistically significant. Analyses were undertaken using SPSS, version 27.0 (IBM, Armonk, NY), and figures were generated using Prism 6.0 (GraphPad Software, San Diego, CA).

**Table 1. Patient characteristics at enrollment**

Characteristics	Overall (N = 49)	HFrEF (n = 16)	HFmEF (n = 5)	HFpEF (n = 28)
Age, y	86 (83-93)	86 (81-93)	95 (83-95)	87 (84-90)
Sex (female)	28 (57.1)	5 (31.2)	3 (60.0)	20 (71.4)
Living alone	15 (30.6)	6 (37.5)	2 (40.0)	7 (25.0)
LVEF, %	50.7 ± 17.5	29.6 ± 8.1	46.1 ± 3.5	63.5 ± 8.3
NYHA class				
II	2 (4.1)	0 (0.0)	0 (0.0)	2 (7.1)
III	42 (85.7)	13 (81.3)	5 (100.0)	24 (85.7)
IV	5 (10.2)	3 (18.8)	0 (0.0)	2 (7.1)
Cardiac biomarker*				
NT-proBNP, pmol/L, mean ± SD	704.7 ± 935.0	962.4 ± 1117.1	883.3 ± 733.6	539.4 ± 844.0
NT-proBNP, pmol/L, median (IQR)	410.0 (207.0–601.0)	504.0 (416.8–997.0)	580.0 (465.0–1150.0)	248.0 (179.0–535.0)
Clinical and cardiovascular risk factors				
Hypertension	39 (79.6)	12 (75.0)	5 (100.0)	22 (78.6)
Coronary artery disease/ischemic heart disease	26 (53.1)	9 (56.3)	3 (60.0)	14 (50.0)
Stroke/transient ischemic attack history	18 (36.7)	8 (50.0)	2 (40.0)	8 (28.6)
Atrial fibrillation	36 (73.5)	12 (75.0)	4 (80.0)	20 (71.4)
Chronic kidney disease	17 (34.7)	6 (37.5)	2 (40.0)	9 (32.1)
Diabetes mellitus	21 (42.9)	7 (43.8)	3 (60.0)	11 (39.3)
Chronic obstructive pulmonary disease	5 (10.2)	2 (12.5)	0 (0.0)	3 (10.7)
Asthma	3 (6.1)	2 (12.5)	0 (0.0)	1 (3.6)
Cognitive impairment	13 (26.5)	5 (31.3)	2 (40.0)	6 (21.4)
Dementia	10 (20.4)	4 (25.0)	2 (40.0)	4 (14.3)
Vital signs				
SBP, mm Hg	118.4 ± 17.9	118.9 ± 15.4	110.0 ± 12.0	119.7 ± 20.0
DBP, mm Hg	59.3 ± 10.0	61.0 ± 11.7	52.4 ± 9.1	59.6 ± 8.8
Pulse, bpm	69.5 ± 11.9	70.4 ± 9.8	71.0 ± 18.6	68.8 ± 12.1
Weight, kg	65.8 ± 14.3	63.1 ± 14.0	56.7 ± 10.2	69.0 ± 14.4
Laboratory measurements				
Sodium, mmol/L	139.7 ± 3.5	139.6 ± 3.2	140.4 ± 3.7	139.7 ± 3.7
Potassium, mmol/L	4.3 ± 0.5	4.4 ± 0.6	4.0 ± 0.5	4.2 ± 0.5
Creatinine, µmol/L	134.9 ± 73.3	136.9 ± 66.5	193.2 ± 171.4	123.3 ± 44.3
Medication use				
β-blocker	34 (69.4)	12 (75.0)	4 (80.0)	18 (64.3)
ACE-I/ARB/ARN-I	25 (51.0)	9 (56.3)	2 (40.0)	14 (50.0)
Mineralocorticoid receptor antagonist	11 (22.4)	3 (18.8)	1 (20.0)	7 (25.0)
Hydralazine/nitrate	5 (10.2)	3 (18.8)	1 (20.0)	1 (3.6)
Diuretics	49 (100.0)	16 (100.0)	5 (100.0)	28 (100.0)
Digoxin	8 (16.3)	6 (37.5)	0 (0.0)	2 (7.1)
Aspirin	10 (20.4)	4 (25.0)	2 (40.0)	4 (14.3)
Oral anticoagulation	30 (61.2)	11 (68.8)	2 (40.0)	17 (60.7)
Calcium-channel blocker	19 (38.8)	4 (25.0)	2 (40.0)	13 (46.4)
Statin	32 (65.3)	11 (68.8)	3 (60.0)	18 (64.3)
Risk scores				
MAGGIC risk score	31.4 ± 4.8	33.6 ± 6.3	32.4 ± 1.3	30.0 ± 3.7
Risk of dying within 1 y, %	29.3 ± 12.5	35.3 ± 18.1	30.2 ± 3.2	25.6 ± 7.8
Risk of dying within 3 y, %	56.8 ± 14.3	62.9 ± 18.0	60.4 ± 4.6	52.6 ± 11.8
Frailty Index <sup>†</sup>	0.43 ± 0.12	0.44 ± 0.12	0.42 ± 0.14	0.44 ± 0.12

Values are n (%), median (interquartile range), or mean ± standard deviation. LVEF cutoffs: HFmEF 41%-49%; LVEF ≤ 40% was classified as HFrEF; LVEF ≥ 50% was classified as HFpEF.

ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; ARN-I, angiotensin receptor-neprilysin inhibitor; bpm, beats per minute; DBP, diastolic blood pressure; HF, heart failure; HFmEF, HF with a mid-range ejection fraction; HFpEF, HF with preserved ejection fraction; HFrEF, HF with reduced ejection fraction; LVEF, left ventricular ejection fraction; MAGGIC, **M**eta-**A**nalysis **G**lobal **G**roup **i**n **C**hronic **H**eart **F**ailure; NT-proBNP, N-terminal pro-hormone brain natriuretic peptide; NYHA, New York Heart Association; SBP, systolic blood pressure.

\* Sample size is smaller due to data incompleteness.

<sup>†</sup> Frailty Index (FI) is an 11-item scale constructed from the 70-item instrument CHSA-FI (Canadian Study of Health and Aging) according to the “accumulating deficit” concept in measuring frailty. FI is the ratio of the number of present items to the total number of items assessed; each item was given equal weight in the scoring of the FI. FI has been applied to the national database and shown to correlate with postoperative mortality and morbidity across all surgical specialties.<sup>15</sup> In this large study, postoperative mortality markedly increased once the FI exceeded 0.36.

## Results

The study cohort consisted of 49 patients with HF (43% male), with a median age of 86 years (range: 83-93 years). During the 1 year of follow-up after enrollment, 18 patients died, and 31 survived, yielding a 1-year mortality rate of 36.7%. No patients were lost to follow-up, and all patients were actively followed until their death or to 1 year. Of the

enrolled patients, 16 had HF and reduced ejection fraction, and 28 had HF and preserved ejection fraction. Comorbidities among enrolled patients were common, such as hypertension (80%), coronary artery disease (53%), atrial fibrillation (74%), diabetes (43%), chronic kidney disease (35%), and cognitive impairment (27%; [Table 1](#)). The mean N-terminal pro-hormone brain natriuretic peptide was 705 pmol/L at

**Table 2. Cardiology virtual visit–related performance measures**

Performance metrics	Frequency
Clinical evaluations	
Jugular venous pressure assessable, %	90.00 ± 0.19
Bloodwork surveillance, d	17.03 ± 14.14
Medical therapy	
Cardiac medication adjustment, %	56.95 ± 0.28
Diuretics adjustment, %	44.45 ± 0.27
Process measures	
Average follow-up interval, d	51.66 ± 37.15
Average virtual visits per patient, n	6.94 ± 4.38

Frequencies of performance metrics indicate the mean (± standard deviation), for encounters during which the corresponding activities were performed.

enrollment, and a MAGGIC risk score predicted a 1- and 3-year mortality of 29% and 57%, respectively.

After enrollment, all interactions with the HF cardiologist were virtual. Patients on average had 5 nurse-facilitated virtual assessments, with a mean interval between visits of 50 days. No visits were aborted due to technical issues, and no patients were brought into the clinic after enrollment. Changes to cardiac medications occurred during 57% of visits. Home bloodwork occurred on average every 17 days (Table 2). Compared with the year prior to enrollment, thiazide diuretic adjustment occurred more frequently after enrollment (Fig. 2).

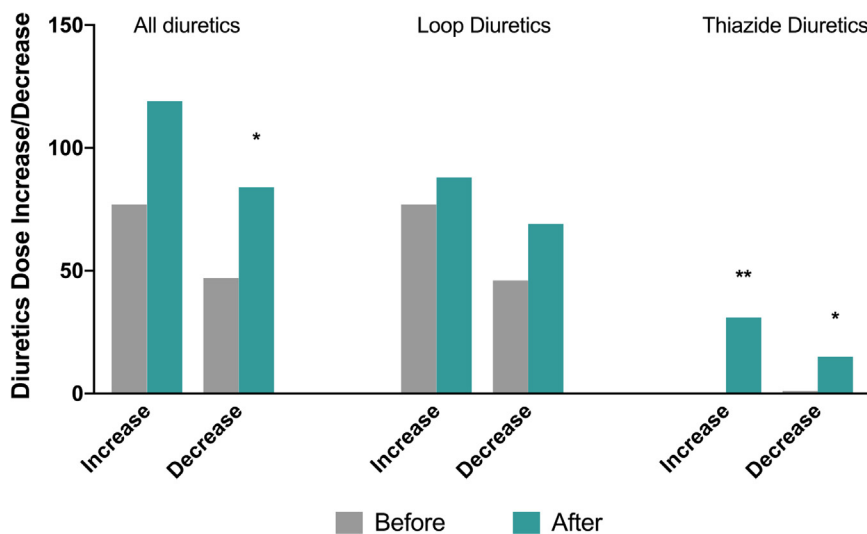
Compared with the year prior to enrollment, patients had a statistically lower mortality-adjusted all-cause hospitalization annual rate in the year following enrollment (2.57 vs 1.78,  $P < 0.0001$ ). The number of mortality-adjusted all-cause hospitalization days was also significantly lower in the year following enrollment, compared with the year prior to enrollment (27.2 vs 21.4,  $P < 0.0001$ ). Finally, there was also a reduction in the number of all-cause ED visits (3.10 vs 2.27,  $P = 0.003$ ). There was no difference in outcomes between those with heart failure with reduced ejection fraction vs those with heart failure with preserved ejection fraction (Table 3).

Of the 49 patients, 37 (76%) had fewer mortality-adjusted all-cause hospitalizations in the year after enrollment compared with the year prior to enrollment, whereas 6 patients of the 49 (12%) had more all-cause mortality-adjusted admissions 1 year after enrollment, compared with the number 1 year prior to enrollment. Of the 49 patients, 40 (82%) had fewer mortality-adjusted days in the hospital after enrollment, compared with the number prior to enrollment, and 6 patients out of 49 (12%) had more mortality-adjusted days in the hospital after enrollment, compared with prior to enrollment (Figs. 3 and 4).

### Discussion

We implemented a nurse-assisted, virtual care, video-based program to follow homebound, frail, and older patients with HF. We found that replacing ambulatory HF in-person clinics with nurse-assisted virtual visits is feasible and was associated with significantly fewer hospitalizations, days in the hospital, and ED visits.

One of the main strengths of this study is that it enrolled not only patients with all subtypes of HF but also high-risk, frail, older patients who are typically excluded from interventional HF studies but remain at significant risk for hospitalization and ED visits. Characterization of the cohort as high risk is supported by the even higher observed mortality rate than the already high rate predicted by the MAGGIC risk score, which does not consider homebound status or frailty. We were able to demonstrate a clinically meaningful improvement in patient-centred outcomes in this high-risk population. Furthermore, we enrolled patients irrespective of their socioeconomic status. Visits were provided free of charge to the patients, who were not required to have an Internet connection or technology to facilitate videoconferencing. For those who could not afford a nominal charge for home bloodwork, this was also provided free of charge to the patient through the public healthcare system. Ancillary costs related



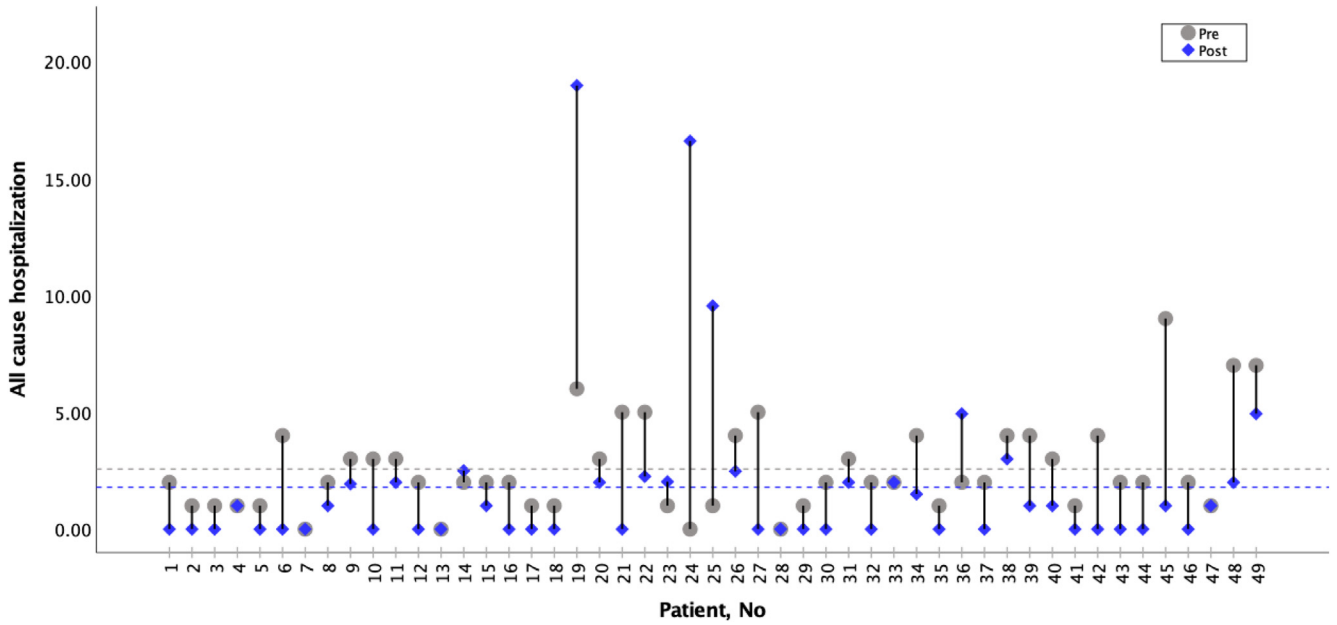
**Figure 2.** Total mortality-adjusted diuretic dose changes for 1 year before vs after enrollment were compared. Thiazide diuretic adjustment occurred more frequently after enrollment. (\* $P < 0.05$ ; \*\* $P < 0.01$ ).

**Table 3. Hospitalization, hospital days, emergency department visits 1 year before and 1 year after enrollment in the telemedicine program**

Outcome	Overall (N = 49)			HFpEF (n = 28)			HFrfEF (n = 16)		
	Pre	Post	<i>P</i>	Pre	Post	<i>P</i>	Pre	Post	<i>P</i>
<b>Cardiovascular hospitalization</b>									
Unadjusted									
Mean (SD)	1.63 (1.64)	0.35 (0.56)	< 0.0001	1.61 (1.97)	0.39 (0.57)	0.002	1.63 (1.15)	0.25 (0.45)	0.001
Median (IQR)	1 (1–2)	0 (0–1)		1 (0–2)	0 (0–1)		1 (1–2)	0 (0–0.25)	
Adjusted									
Mean (SD)	1.63 (1.64)	0.81 (2.44)	< 0.0001	1.61 (1.97)	0.59 (0.87)	0.023	1.63 (1.15)	1.32 (4.13)	0.007
Median (IQR)	1 (1–2)	0 (0–1)		1 (0–2)	0 (0–1.06)		1 (1–2)	0 (0–0.25)	
<b>All-cause hospitalization</b>									
Unadjusted									
Mean (SD)	2.57 (1.96)	0.82 (1.05)	< 0.0001	2.43 (2.13)	0.89 (1.17)	< 0.0001	2.63 (1.59)	0.75 (0.93)	0.002
Median (IQR)	2 (1–4)	0 (0–1)		2 (1–3)	0.5 (0–1.25)		2.5 (1–4)	0.5 (0–1)	
Adjusted									
Mean (SD)	2.57 (1.96)	1.79 (3.77)	< 0.0001	2.43 (2.13)	1.84 (3.91)	0.031	2.63 (1.59)	1.82 (4.07)	0.018
Median (IQR)	2 (1–4)	0 (0–2)		2 (1–3)	0.5 (0–2)		2.5 (1–4)	0.5 (0–2)	
<b>All-cause hospitalization days</b>									
Unadjusted									
Mean (SD)	27.16 (33.21)	8.82 (16.21)	< 0.0001	27.11 (38.43)	9.43 (17.52)	< 0.0001	26.75 (28.01)	7.06 (14.31)	0.002
Median (IQR)	18 (7–36)	0 (0–8)		15 (6–27.5)	1 (0–5.75)		19 (12.25–34.5)	0.5 (0–6)	
Adjusted									
Mean (SD)	27.16 (33.21)	21.40 (51.14)	< 0.0001	27.11 (38.43)	17.4 (36.8)	0.012	26.75 (28.01)	22.05 (62.12)	0.007
Median (IQR)	18 (7–36)	0 (0–12)		15 (6–27.5)	1 (0–12.54)		19 (12.25–34.5)	0.5 (0–10.50)	
<b>All-cause ED visits</b>									
Unadjusted									
Mean (SD)	3.10 (2.82)	1.33 (1.77)	< 0.0001	2.82 (2.52)	1.57 (2.04)	0.001	3.56 (3.37)	1 (1.21)	0.01
Median (IQR)	2 (1–4)	1 (0–2)		2 (1–3.25)	1 (0–2)		3 (1.75–4.25)	1 (0–1.25)	
Adjusted									
Mean (SD)	3.10 (2.82)	2.27 (3.58)	0.003	2.82 (2.52)	2.47 (3.55)	0.042	3.56 (3.37)	2.07 (4.07)	0.073
Median (IQR)	2 (1–4)	1 (0–2.5)		2 (1–3.25)	1.22 (0–2.60)		3 (1.75–4.25)	1 (0–2.13)	

Post-enrollment (Post) results are presented as both nonadjusted and mortality-adjusted annual rate. Mortality-adjusted annual rate is defined as the number of events (hospitalization, hospital days, emergency department [ED] visits) multiplied by 365/days followed after enrollment. Statistical analysis was not conducted for the heart failure with mid-range ejection fraction group, owing to small sample size (n = 5). There was no statistically significant difference in the reduction in hospitalization, hospital days, or ED visits between subgroups of heart failure (HFpEF, HFrfEF).

IQR, interquartile range; HFpEF, heart failure with preserved ejection fraction; HFrfEF, heart failure with reduced ejection fraction; Pre, pre-enrollment; SD, standard deviation.

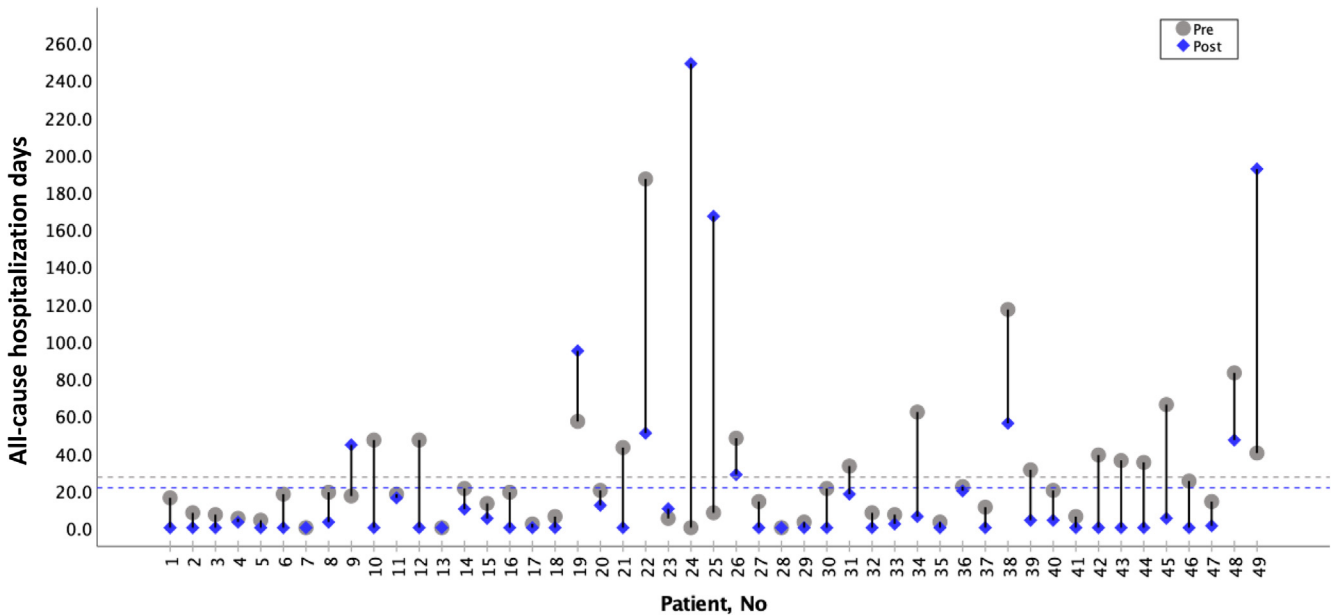


**Figure 3.** Mortality-adjusted all-cause hospitalizations 1 year before (pre) and 1 year after (post) enrollment, by patient. Of the 49 patients, 37 had fewer mortality-adjusted all-cause hospitalizations in the year after enrollment compared with the year prior to enrollment, whereas 6 of the 49 patients had more all-cause mortality-adjusted admissions 1 year after enrollment compared to 1 year prior to enrollment. An overlapping diamond and square indicates no change.

to transportation and parking associated with in-person visits were avoided for the patients and their caregivers.

The main weakness of this study is that it was a small, single-centre, pragmatic, quasi-experimental, short-term, pre–post study, with results that may not be generalizable to other clinical settings or institutions. Specifically, older patients with HF

living in long-term care or nursing-home settings were excluded and may be more likely to benefit from virtual assessments. Also, as there was no standard-of-care comparison arm, we cannot draw conclusions about what effect this program may have had on mortality, although we note that for this patient population, mortality may not be as relevant an outcome.



**Figure 4.** Mortality-adjusted all-cause hospitalization days 1 year before (pre) and 1 year after (post) enrollment, by patient. Of the 49 patients, 40 had fewer mortality-adjusted days in the hospital after enrollment compared to prior to enrollment, whereas 6 of the 49 patients had more mortality-adjusted days in the hospital after enrollment compared to prior to enrollment. An overlapping diamond and square indicates no change.

We cannot make any conclusions as to which elements of our program were necessary to achieve a reduction in ED visits and hospitalizations. Specifically, the significant reduction of observed ED visits and hospitalizations in the post-enrollment period could have been related simply to more frequent follow-up, access to specialized HF care, or the institution of nurse home visits. However, we postulate that increased access to specialized HF care was only possible because of the virtual nature of the specialist visits for these homebound patients who have significant known obstacles to visiting in-person clinics. Given that the nurse specialist is not trained in volume assessment, medication prescription, or the goals of care discussion for advanced HF, the HF physician was an integral part of the model.

Finally, we acknowledge that the intervention is neither fully virtual nor inexpensive from a health system perspective, as it requires an on-site clinical nurse specialist, which may not be an available resource in many jurisdictions. That said, many older patients lack digital literacy and may not be ready to partake in telemedicine<sup>10</sup>; thus, the on-site nurse was also critical to this model's success. Although the upfront costs to the healthcare system may be high, the model may be economically sustainable via its ultimate reduction of hospital and ED use. Although we did not obtain patient/caregiver satisfaction data, we note that no patient was lost to follow-up, and all patients voluntarily continued in the program until death or to 1 year.

Despite improved technological fidelity, prior to the pandemic, use of virtual visits in the management of HF was limited. This lack of use was likely related to concerns about the safety of replacing in-person clinic visits, concerns about both patient and provider familiarity with videoconferencing technology, and outdated reimbursement models.<sup>8</sup> In the context of the current global pandemic, these theoretical obstacles were quickly challenged, and at least one group has outlined a strategy of combining virtual visits and telemonitoring to follow patients with advanced HF who are implanted with a left ventricular assist device, in order to obviate the need for in-person visits.<sup>11</sup> However, published data on the safety and efficacy of replacing in-person visits with virtual visits for patients with HF thus far also have been quite limited; a recent pilot study of 108 virtual visits demonstrated a trend toward lower no-show rates.<sup>8</sup> Moreover, another recent article demonstrated an acceptable fidelity of video-based JVP assessments.<sup>12</sup> However, this study is among the earliest demonstrating that nurse-assisted virtual visits using videoconferencing technology significantly reduce ED visits and hospitalizations, specifically in frail and older homebound patients with HF.

We believe the success of our intervention can be explained in part by improved access to care and timely adjustments of medical therapy. Nearly 50% of the virtual assessments resulted in a change in diuretic dosing, and medication changes occurred more frequently after enrollment. Diuretic adjustment is believed to be the major reason that the **CardioMEMS Heart Sensor Allows Monitoring of Pressure to Improve Outcomes in NYHA Class III Patients (CHAMPION)** trial demonstrated a reduction in hospitalizations in patients with HF who had been implanted with a hemodynamic monitor.<sup>13</sup> Another explanation for our intervention's

success is that patients seen in the home have a certain momentum to remain at home. Frail patients who attend a clinic and are congested are sometimes admitted directly from the clinic, to simplify their management.<sup>14</sup> Attending a clinic is often stressful and physically exhausting and may precipitate at least the perception of a significant exacerbation, thus also contributing to an increased likelihood of hospitalization after an in-person visit, vs after a virtual visit.<sup>14</sup> Finally, home visits may identify issues that may not be easily identifiable during clinic-based visits. Although we did not collect quantitative data on this metric, in some instances, our program was able to identify missing medications or incorrect labeling of medication bottles, as well as dietary indiscretions, based on presence of foods observed in the home.

Further studies should evaluate the degree to which on-site nursing support is a critical component of this model; from our experience, the presence of the clinical nurse specialist allowed for technology issues to be managed and for the assessments to be successfully completed. Moreover, the low barrier to entry for patients in this program raises the possibility that this model could improve the care of patients with HF who have financial obstacles, in addition to physical obstacles to accessing specialized HF care, such as those living outside of major urban centres and those who cannot afford to take time off work to travel to medical appointments. Recent US data obtained during the pandemic suggest that these patients may be eager to adopt this approach.<sup>7</sup>

## Conclusion

We present a nurse-assisted, virtual, patient-centred model targeting frail and older homebound patients with HF, which we found to be acceptable or even preferable for outpatient care. This conclusion is strengthened by the context of care during the pandemic, as these patients are at increased risk of COVID-19 complications, and the general consensus is that they should remain at home whenever possible. We believe that this strategy, possibly combined with evolving and increasingly ubiquitous telemonitoring technologies, merits further evaluation as a means to reduce the overall healthcare resource requirement often associated with high levels of avoidable acute-care service utilization for this population of homebound patients, and others.

## Acknowledgements

The Ontario Health Toronto Region (OH Toronto) Urban Specialist Telemedicine Program for Homebound Elders is a model of care funded by Ontario Health and implemented by the Healthy Ageing and Geriatrics Program and Department of Nursing at Sinai Health System (Toronto). The authors thank Nicoda Foster, Mary Ann Hamelin, Richard Norman, and Janny Lee, who helped to support the implementation of this program.

## Funding Sources

This research project was generously funded by the Sinai Health System's Healthy Ageing and Geriatrics Program (Toronto).



## Disclosures

Jeremy Kobulnik has received an honorarium for participating in an advisory board for Bayer Inc. The other authors have no conflicts of interest to disclose.

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## Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjopen.ca/> and at <https://doi.org/10.1016/j.cjco.2021.08.015>.