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Clinical Heart fAilure Management Program: Changing the practice by partnering primary care and specialists (CHAMP-HF)☆

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ABSTRACT

Background: While significant gains were made in the management of heart failure (HF), most patients are still diagnosed when they are acutely ill in hospital, often with advanced disease. Earlier diagnosis in the community could lead to improved outcomes. Whether a partnership and an educational program for primary care providers (PCP) increase HF awareness and management is unknown.

Methods: We conducted an observational study between March 2019 and June 2020 during which HF specialists gave monthly HF conferences to PCP. Using a pre-post design, medical charts and administrative databases were reviewed and a questionnaire was completed by participating PCP. Primary and secondary endpoints included: 1) the number of patients diagnosed with HF, 2) implementation of GDMT for patients with HFrEF; 3) PCPs' experience and confidence.

Results: Six PCP agreed to participate. Amongst the 11,909 patients of the clinic, 70 (0.59 %) patients met the criteria for HF. This number increased by 28.6 % (n = 90) after intervention. Increased use of GDMT for HFrEF patients at baseline (n = 35) was observed for all class of agents, with doubling of patients on triple therapies, from 8 (22.9 %) to 16 (45.7 %), p = 0.0047. Self-confidence on HF management was low (1, 16.7 %) but increased after the educational intervention of physicians (3, 50 %).

Conclusion: An educational and collaborative approach between HF specialists and community PCP increased the number of new HF cases diagnosed, enhanced implementation of GDMT in patients with HFrEF and increase PCPs' confidence in treating HF, despite being conducted during the COVID-19 pandemic.

Abbreviations: **ACC**, American College of Cardiology; **ACEI**, Angiotensin-Converting Enzyme Inhibitors; **AF**, Atrial Fibrillation; **AHA**, American Heart Association; **ARB**, Angiotensin II Receptor Blockers; **ARNI**, Angiotensin Receptor-Neprilysin Inhibitors; **ATC**, Anatomical Therapeutic Chemical; **BEYOND II**, Observational study evaluating the effectiveness of physician-targeted education for improving glycemic management of patients with type 2 diabetes; **BNP/NT-ProBNP**, Brain Natriuretic Peptide/N-Terminal Pro-Brain Natriuretic Peptide; **CCS**, Canadian Cardiovascular Society; **CHADS**, Congestive heart failure, Hypertension, Age ≥75 years, Diabetes, Stroke; **CHAMP**, Clinical Heart Failure Management Program; **CKD**, Chronic Kidney Disease; **CMMR**, Clinique Médicale Maisonneuve-Rosemont; **COPD**, Chronic Obstructive Pulmonary Disease; **EMR**, Electronic Medical Records; **GDMT**, Guideline-Directed Medical Therapy; **GP**, General Practioner; **HF**, Heart Failure; **HFpEF**, Heart Failure with Preserved Ejection Fraction; **HFrEF**, Heart Failure with Reduced Ejection Fraction; **MHI-HFC**, Montreal Heart Institute Heart Failure Clinic; **MRA**, Mineralocorticoids Receptor Antagonists; **NYHA**, New York Heart Association; **PCP**, Primary Care Physicians; **QHFS**, Quebec Heart Failure Society; **RAMQ**, Régie de l'Assurance Maladie du Québec; **WHO**, World Health Organization.

☆ All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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1. Introduction

Heart failure (HF) is a major cause of morbidities and mortality. Even with the best therapies, the 5-year survival rate is worse than for most cancers [1]. HF affects 2 % of the Western population, with 750,000 Canadians actually living with heart failure (HF) and 100,000 being diagnosed each year [2]. Its prevalence increases with age, reaching up to 20 % over the age of 75 years [3], a proportion expected to increase due to the aging population. The majority presents with mild symptoms (NYHA functional class II) [2], and is being followed by primary care providers (PCP) in the community [4].

HF is a clinical syndrome, with typical signs and symptoms, confirmed by measurement of natriuretic peptides and echocardiography.[5,6] Nevertheless, early diagnosis may be difficult, symptoms being non-specific (ex: shortness of breath, fatigue) [7], assumed to be secondary to the natural aging process, associated to/or competing with other conditions (atrial fibrillation (AF), chronic obstructive pulmonary disease (COPD), renal disease) or overlapping with co-morbidities (diabetes, obesity, age) that can cloud the precise diagnosis [8]. This may lead to undetected HF [9].

Consequently, most patients are diagnosed late in the course of their disease, in hospital with acute decompensation, while as many as 50 % of these patients have had symptoms for up to 5 years [10–14]. This may explain the high and unchanged mortality rate of 50 %, 5 years after a diagnosis of HF.[15] This delay in proper HF diagnosis may lead to poor quality of life and decreased survival, that could potentially be alleviated if diagnosed early and treated appropriately. Indeed, progress in treatment, including the quadruple combination of agents (Angiotensin Receptor-Neprilysin Inhibitors (ARNI), beta-blockers, Mineralocorticoids Receptor Antagonists (MRA), and sodium glucose cotransporter-2 (SGLT2) inhibitors) recommended for patients with HF and reduced ejection fraction (HFrEF) has led to a remarkable reduction in mortality of 73 % over 2 years [16,17]. Despite these impressive results, the proportion of optimally managed HF patients in the community remains low, with less than 1 % of patients with HFrEF receiving triple therapy (ACE/ARB/ARNI, beta-blocker, and MRA) at target doses [18].

Many approaches have been suggested to improve this dismal adherence to guidelines. Amongst them, physician education alone or combined with audit and feedback may lead to improvement in professional practice [19,20]. In this longitudinal educational program called Clinical Heart Failure Management Program (CHAMP), we aimed to raise awareness and management of HF by PCP, who are most likely to be the first point of contact for patients presenting initially with signs and symptoms suggestive of HF [21].

2. Methods

2.1. Study design and setting

We conducted an educational partnership program between the Montreal Heart Institute Heart Failure Clinic (MHI-HFC), a tertiary care center, and a family practice group, the Clinique Médicale Maisonneuve-Rosemont (CMMR). CHAMP was a longitudinal interventional study of 15 months' duration with a pre-post comparison design. The primary objective was to increase awareness of PCP toward HF and improve the management of their patients. Fig. 1 depicts the timeframe of the study, divided in 3 phases:

1) Baseline: Data collection from the previous year ("look-back window" March 28th, 2018 to March 28th, 2019);
2) Educational Intervention (March 29th, 2019 to December 18th, 2019);
3) Observation and final data collection (December 19th, 2019 to June 28th, 2020).

2.2. Study setting and participants

The CMMR is a private urban family practice group in Montreal, Canada. PCP were invited to participate on a voluntary basis without financial compensation, except for the meal during the luncheon educational program ("lunch and learn"). PCP with a main practice focus in pediatrics and/or obstetrics were excluded. The family practice group also comprises two nurses and one pharmacist, who could attend the luncheon conferences as well as non-participating PCP, but made no commitment to do so. Therefore, we elected to use the total number of patients with HF followed at the clinic to account for possible cross-

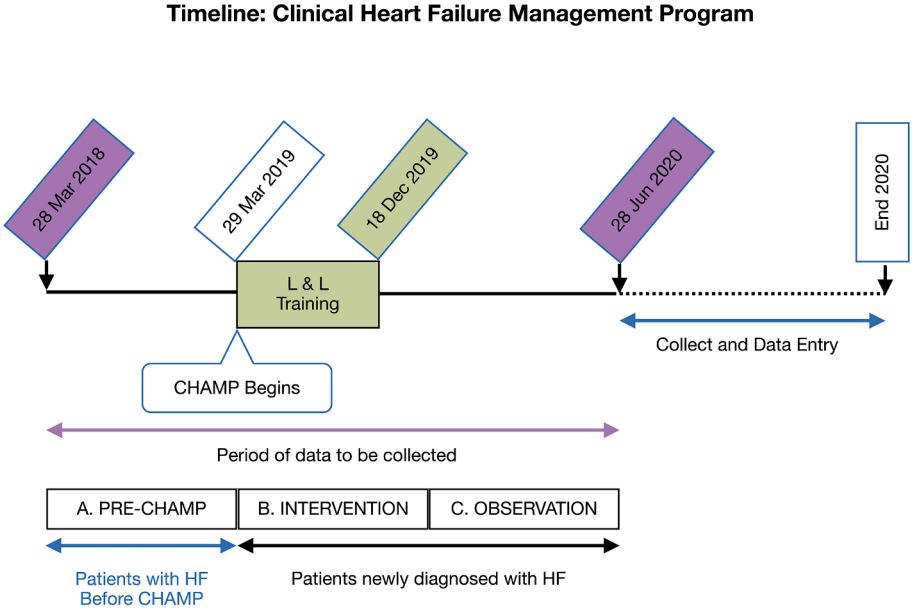


Fig. 1. . Timeline: Clinical Heart Failure management program. PRE-CHAMP (March 28th, 2018, to March 28th, 2019): Patients with a diagnosis of HF were identified at the CMMR for the 12-months period prior to the implementation of CHAMP. **INTERVENTION (March 29th, 2019, to December 18th, 2019):** Duration of the educational program. **OBSERVATION (December 19th, 2019, to June 28th, 2020):** A 6-month observational period followed the end of the active educational program.

contamination.

2.3. Questionnaire on experience and confidence on HF management

Participating PCP completed a survey at the beginning and at the end of the program, specifically regarding brain natriuretic peptides (BNP and NT-proBNP) measurements, echocardiography, referral habits, HF guidelines awareness, their confidence about treating HF patients and on initiation/ titration of Guideline-directed Medical Therapy (GDMT) as well as other medications, using Polar and Likert scale questions; in addition they were asked about their experience of the program (Appendix 1).

3. Quality improvement intervention

3.1. Stage 1 – baseline data collection

There is no specific ambulatory diagnostic code for HF in the governmental reimbursement database nor in the electronic medical record (EMR) used at CMMR. However, physicians' billing varies according to frailty vulnerability codes (Appendix 2), including comorbidities (COPD-code 02; diabetes-07; chronic kidney disease or hepatic disease- 09; AF, CHADS score $\geq$ 2-code 13). Cardiovascular conditions (03) include HF but also coronary artery disease and refractory hypertension (grade 3) altogether. Noteworthy, the physicians are not allowed to have more than 3 codes for a given patient. So, we elected to have a conservative approach and derived the total number of patients diagnosed with HF at baseline (and follow-up) using a two steps approach: 1) Query of the CMMR's EMR for patients with a code "03"; 2) Manually review individual charts for confirmation (or not) of the diagnosis of HF. Then, clinical characteristics, laboratory results and medications were retrieved from the EMR of all HF patients followed at the CMMR (Appendix 3). Cardiovascular medications were reported according to the level 2 Anatomical Therapeutic Chemical (ATC) classification and preferred term using the World Health Organization (WHO) drug dictionary (Version Mar. 2018). Frequency of use of cardiovascular medications are presented by therapeutic class and preferred term.

3.2. Stage 2: intervention program

An educational program and a HF referral pathway to the MHI-HFC were developed:

A. The MHI-HFC organized jointly with the Canadian Cardiovascular Society a half day symposium on HF guidelines for PCP of Montreal on March 28th, 2019; launching the educational program.
B. Luncheon conferences on different aspects of HF, on a monthly basis (n = 10) Appendix 4.
C. A one-day preceptorship at the MHI-HFC for CMMR staff.
D. A rapid referral pathway to the MHI-HFC for patients with suspected or proven HF, upon request of the PCP or phone consultation within 24 h.
E. Educational tools from the Canadian Heart Failure Society (https://heartfailure.ca/) and the Quebec Heart Failure Society (QHFS) were provided (https://sqic.org/).

3.3. Stage 3: after CHAMP data collection

The same method as phase one was used.

4. Outcomes

The Primary endpoint was the proportion of patients followed by the CMMR and diagnosed with heart failure between baseline (March 29th, 2019) at follow-up (15-month).

Secondary outcomes:

1. The ability of CHAMP to improve HF diagnosis, investigation, and managemen, defined as implementation of GDMT for patients with HFrEF:
   i. Proportion of patients receiving each specific classes of the recommended drugs;
   ii. Proportion of patients optimized, either at target dose or maximally tolerated dose [according to biological (potassium, renal function) and physiological (blood pressure, heart rate) limitations]*(22);*
   iii. Proportion of patients receiving the recommended combination of ARB/ACEI/ARNI, beta-blockers and MRA;
2. Confidence of the participating physicians regarding HF management before/after CHAMP.

Exploratory outcomes:

3. Resources utilization and referral patterns:
   i. number of consultations overall
   ii. number of visits for cardiovascular reasons (shortness of breath, peripheral edema, chest pain and/or palpitations).
4. Evaluation of PCP experience during CHAMP

The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval of the protocol by the Montreal Heart Institute research ethical board; participating PCP provided written informed consent. The access to MHI patients' medical charts was authorized by the *Directeur des services professionnels* of the Montreal Heart Institute and the access to CMMR patients' medical charts was authorized by the Commission d'accès à l'information du Québec.

5. Statistical considerations

5.1. Sample size

Since this program is not hypothesis driven and mostly descriptive, formal sample size calculation is not necessary. Therefore, the sample size is not based on statistical considerations and the studied sample of PCP and the CMMR patients is intended to provide information on the current management of HF patients and on the possible impact of the educational program.

5.2. Statistical analyses

Descriptive statistics for continuous variables include number of patients, mean $\pm$ standard deviation, median with interquartile range (IQR Q1-Q3) or range (minimum–maximum). For categorical variables, number of patients and proportion were presented. Baseline data on the pre-CHAMP HF population (12-month period preceding the implementation of the program, March 28th, 2018 to March 28th, 2019) and prospective data (15-month period post implementation of the program, March 29th, 2019 to June 28th, 2020) on the overall post-CHAMP HF population are presented separately.

Comorbidities at time of initiation of treatment for HF and at the end of CHAMP (i.e. immediately before June 28th, 2020) are summarized using descriptive statistics separately for the pre-CHAMP HF population and for the overall post-CHAMP HF population. The proportion of patients with HF and reduced ejection fraction (HFrEF) on triple therapy and at target/maximum dose were compared between baseline and post-CHAMP using a McNemar test. The patients at target dose have been identified by the principal investigator after medical charts review, including medications, laboratory results and vital signs.

Responses to the survey are summarized using descriptive statistics for the participating PCP. Responses to the most relevant questions are

compared between baseline and post-CHAMP using a McNemar test or a Bowker test.

Prior to all parametric analyses, basic assumptions were checked and if they were violated, non-parametric analyses were performed. Statistical analyses were performed using SAS Version 9.4. All statistical tests were two-sided and performed at a significance level of 0.05. No missing data were imputed.

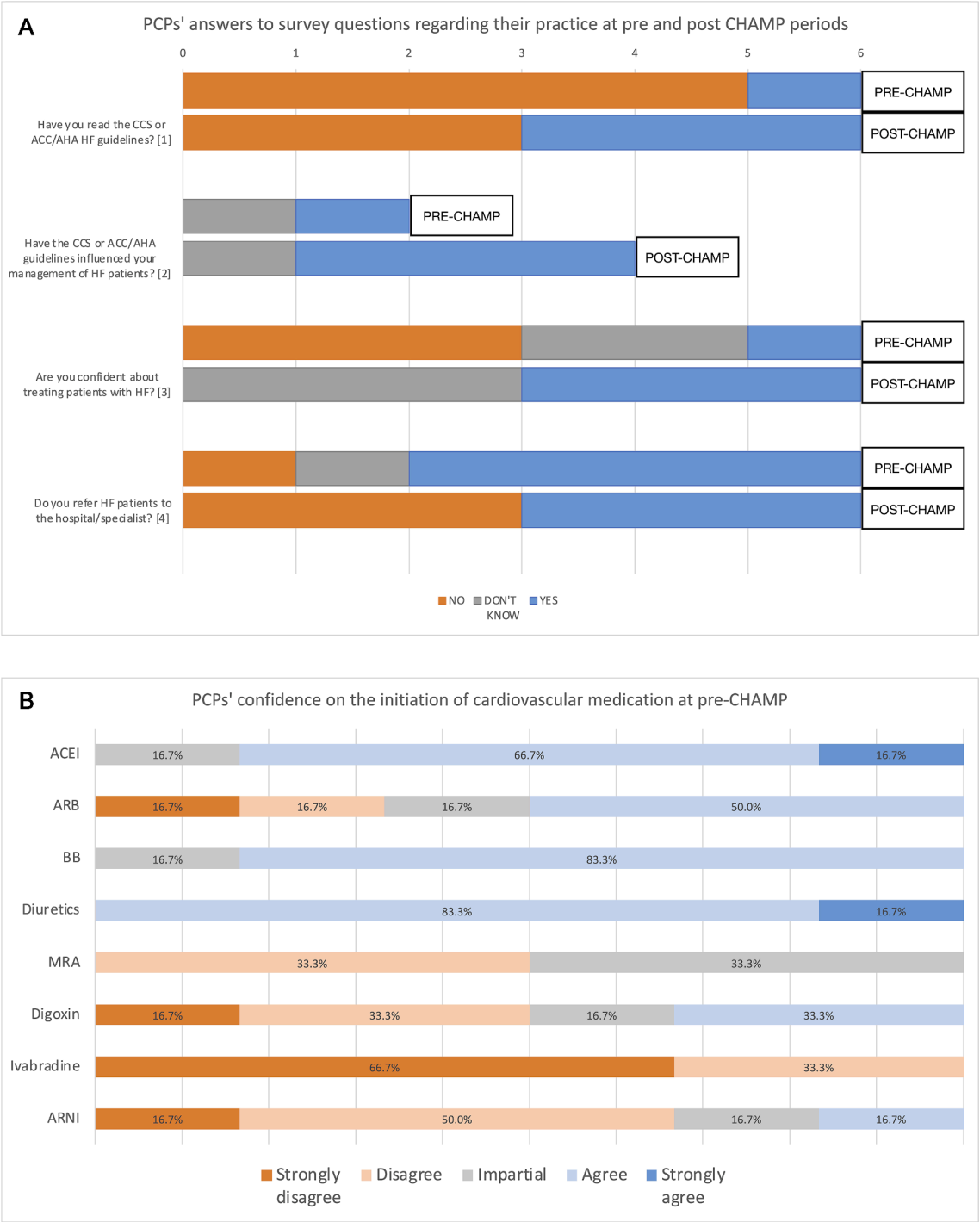
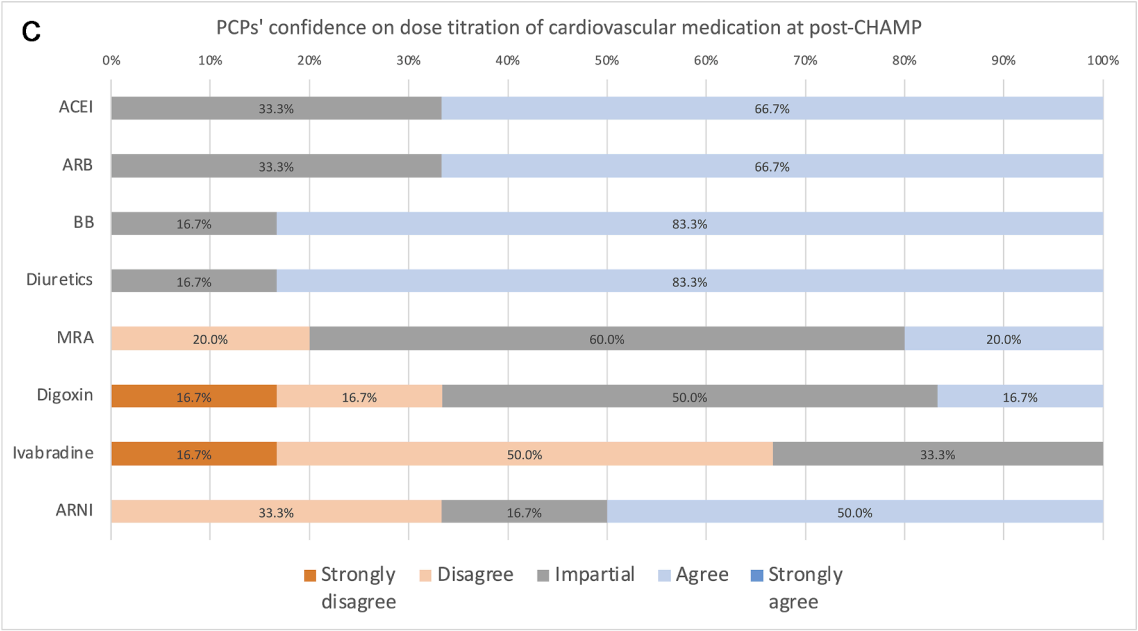


Fig. 2. PCPs' answers to survey (Pre and post CHAMP). Knowledge and Influence of the guidelines. Only 1 participant at baseline and half at follow-up reported having read them; with three times more physicians reporting that they have influenced their practice after the program; Confidence about treating HF patients. The numbers shifted toward increased confidence with half of the physicians reported being more confident to treat HF patients after the program. Reference of HF to specialists. This lack of confidence at baseline translated into only one PCP not referring his HF patients (16. 7 %) compared to half after the program. [1] $p = 0.1573$; [2] Number of physicians too small; [3] $p = 0.3916$; [4] $p = 0.3173$ PCPs' answers to survey on their confidence of HF management PRE- CHAMP; (C. POST-CHAMP): There is a global movement toward increased confidence to care fo HF, as the participants agreed being more confident on the initiation of ACEI (+16.7 %), ARB (+50.0 %), ARNI (+16.7 %), and MRA (+50.0 %). PCPs' perspective on the impacts of CHAMP (before and after). There was no major change regarding the need for a referral pattern and whether improved patient care would result. However, regarding reduced hospital admission, after CHAMP, all participants agreed that the program would be effective on this matter.



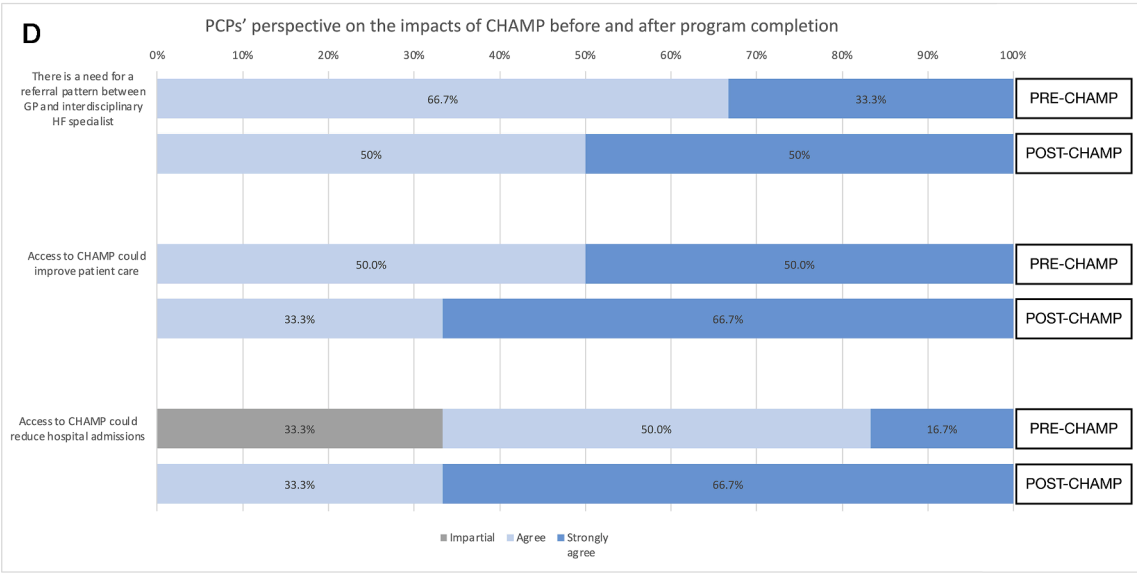


Fig. 2. (*continued*).

6. Results

6.1. Participating primary care providers

6.1.1. Baseline characteristics of PCP

Six of the 17 (35.3 %) eligible PCP practicing at CMMR agreed to join the program; they had a median clinical experience of 21.5 (IQR 14.0–36.0) years. On March 28th, 2018, their median common workload represented 581 (range 7–1197) patients and 27.6 % of the clinic's total volume of patients. They reported following a median of 5 (IQR 2–7) HF patients each.

6.1.2. Participation in CHAMP

The participating PCP completed a median of 6 (range 4–8) out of the 11 educational sessions offered. In addition, two nurses and the pharmacist attended the one-day preceptorships at MHI-HFC, but no PCP. At the end of follow-up, the median caseload of the participating physicians increased to 601 (range 5–1181) patients (+3.53 %), while the median number of HF patients they claimed to individually follow raised to 7 (IQR 5–10; +40 %).

6.1.3. Responses to questionnaire (pre and post-CHAMP)

The PCPs' responses to the survey are represented graphically in Fig. 2. Only 1 (16.7 %) had read the HF guidelines at baseline, and the majority had low level of confidence, with 4 (66.7 %) referring the majority of their patients to a specialist.

After the program, half had read the guidelines, which translated into a global movement toward increased confidence in HF care (50 % reported being confident), including for initiating GDMT (Fig. 2B), (ACEI/ARB:100.0 %; ARNI:33.3 %; and MRA:50.0 %) and titration of these agents (Figure S1) (ACEI/ARB; 66.7 %, ARNI; 50.0 %, and MRA; 20.0 %) in addition to beta-blockers (83.3 %) and diuretics (83.3 %) and lower reference to specialists, with 3 physicians (50.0 %) reporting not doing so (Fig. 2A). The program was globally well received, with reference tools 4 (66.7 %) and case-based discussions 3 (50.0%) being the preferred methods. PCPs all believed (100.0%) that such a program

could have a significant impact on their management of HF and on the overall care they provide (Figure S2).

6.2. Clinic volume and proportion of patients with HF

6.2.1. Baseline characteristics (pre-CHAMP)

The clinic volume and patients' flow are described in the CONSORT chart (Fig. 3). Of the 11,909 adult patients followed at baseline, 698 (5.86 %) had cardiovascular conditions (vulnerability code 03); after chart review, 70 (0.59 % of the cohort or 0.83 % of those aged >40 years) met the criteria for diagnosis of HF. Their characteristics are described in Table 1; they were mostly male (63 %) of a mean age of 67 ± 13 years. Comorbidities were frequent and include dyslipidemia 54 (77.1 %), diabetes 30 (42.9 %), hypertension 52 (74.3 %), renal disease 21 (30.0 %), AF 23 (32.9 %) and COPD 20 (28.6 %). Unfortunately, the NYHA class was not universally documented. Out of these patients, 24 (34.3 %) were followed by CHAMP's participating PCPs.

6.2.2. Overall post-CHAMP HF population

The total volume of patients followed at the CMMR decreased slightly from 11,909 to 11,408 (−4.2%) between March 29th 2019 and June 28th 2020. At the end of the study, 90 (0.79 %) patients had a diagnosis of HF confirmed by chart review, of which 30(33.3 %) were treated by CHAMP participating PCP. Since there was no death in the HF patients, it represents an absolute increase of 20(+28.6 %) new HF diagnosis. Only one patient was referred to the MHI-HFC during the CHAMP study.

6.3. Characteristics of HF patients

Table 1 depicted the characteristics of the HF patients at baseline (n = 70) and at the end of the program (n = 90), which were very similar.

6.3.1. HF patients of the baseline cohort – pre and post CHAMP

Fig. 4A illustrates the main findings in the changes in medication prescribed and optimization between baseline and end of study. Amongst the 70 HF patients at baseline, 35 (50 %) had a reduced ejection fraction (LVEF ≤ 40 %). Most were prescribed ARB/ACEI/ARNI (29, 82.9 %) and beta-blockers (30, 85.7 %), but fewer received MRA (11, 31.4 %) (Fig. 4B). Also, less than half of patients on vasodilators (ARB/ACEI/ARNI) (13, 37.1 %) or beta-blockers (10, 28.6 %) were at target dose and only 7(20.0 %) on MRA (Fig. 4C).

The program led to significant improvement in the use of GDMT for HFrEF patients (n = 35); MRA prescription increased by 17,1%; while the proportion on triple therapy doubled (from 22.9 % to 45.7 %, p = 0.0047) (Fig. 4D), optimization to target doses remained limited (from 5.7 % to 8.6 %, p = 0.3173).

6.4. Resources utilization

6.4.1. Diagnosis procedures

Few patients had diagnostic cardiac procedures performed (Table 2); specifically, the measurement of natriuretic peptides and the evaluation of structural cardiac abnormalities by echocardiography did not seem to be systematically performed by the PCP, despite being an essential part of the diagnostic criteria, based on the universal definition of HF [8].

6.4.2. Clinical follow-up

During the pre-CHAMP period, a median of 3(IQR 1–5) clinical visits per subject occurred, the majority for non-cardiovascular reasons (2; IQR 1–4). Among the overall HF population (n = 90), those numbers only slightly raised post-CHAMP during the educational program, suggesting that CHAMP did not put an extra burden on already overloaded PCP (Table 3).

7. Discussion

We showed the feasibility of a partnership between a specialized HF program and a large family practice group. Salient findings are threefold: 1) the prevalence of patients diagnosed with HF in primary care is very low (0.59 %); the program improved: 2) confidence of the PCP in their management of HF patients; and 3) awareness and management of HF. To our knowledge, this pilot study is the first of its kind to improve early detection and management of HF by PCP in the community.

7.1. Low prevalence of diagnosed HF patients in the community

The prevalence of HF was considerably lower (<1%) than anticipated, even in higher risk patients such as those aged >40 years when compared to the reported age-standardized prevalence of HF in Canada (3.5 %).(23) In high-risk populations (AF, diabetes, COPD, CKD) the estimated prevalence of undiagnosed HFrEF is believed to be conservatively 5 %.(24, 25) However, our findings are in accordance with the 0.5 % prevalence of HF in primary care in unselected patients reported by Rachamin et al., using similar methodology.(26) Billing codes probably underestimate the true prevalence as there is no financial incentive for physicians to diagnose HF. To overcome this known limitation, PCP were asked to provide an estimate of the number of HF patients in their caseload, which was slightly higher than those obtained using codes. Nevertheless, despite the common wisdom that the majority of HF patients are followed in the community, each clinician has only a few in their caseload, hence the very difficult task of optimizing management for this complex population when they are encountered infrequently. It is probable that many HF patients might not even be diagnosed as such, their shortness of breath being attributed to other causes such as advanced age, COPD, or obesity [8]. This is worrisome as many life-saving therapies exist and are most effective when given early in the course of the disease. To raise awareness, some have suggested to look specifically for higher risk features (coronary artery disease, AF, COPD, diabetes, CKD) [27] with reminder embedded directly into the EMR.

7.2. Primary care physicians and the guidelines

The fact that the majority of PCP had not read the HF Guidelines, which are developed by the expert societies to help clinical decision making reflects an unknown unperceived need, given the small number of patients diagnosed with HF in their individual caseload. The program seemed to have raise awareness as the majority claimed to have read them at the end of CHAMP. They also felt more empowered to manage HF patients, which translated into increased use of GDMT and less necessity to refer their HF patients.

7.3. The partnership increases awareness of PCP toward HF and improves management

Regardless of whether we use numbers derived from the billing codes or the physicians' self-reported ones, we found an increase in the number of patients diagnosed with HF. This increase is most probably related to the program, as during the same period the overall clinic volume decreased.

In addition, CHAMP improved the management of patients with clear guidelines recommendations, those with HFrEF, who represented half of the baseline population. After CHAMP, more patients were receiving MRA and ARNI, while the number of patients on triple-therapy doubled. Those improvements were paralleled by a movement toward increased confidence for prescription of more recent treatments (ex: MRA, ARNI). Unfortunately, only a minority was at targeted doses of GDMT at the end, but the follow-up was relatively short and the study ended in the midst of the COVID-19 pandemic, in June 2020.

This kind of partnership between PCP and a specialized team is

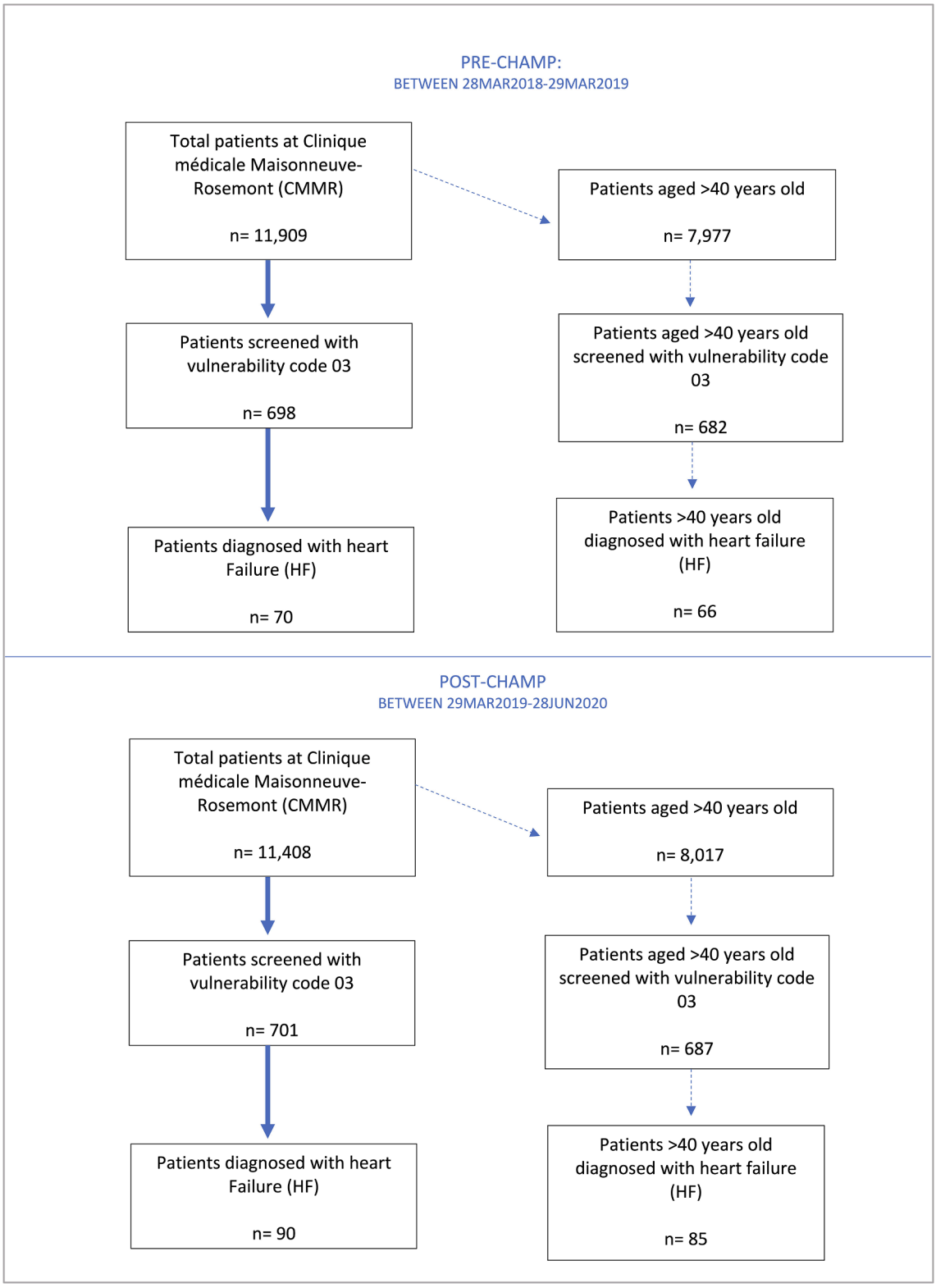


Fig. 3. CONSORT flow chart. At baseline, a total of 11,909 adults (7,977 > 40 years old) patients were registered at the CMMR under the care of 19 PCPs; of these, 698 had the vulnerability codes of interest and 70 (0.59 % of the whole population, or 3.68 HF patients per PCP) had a confirmed diagnosis of HF after chart review. After the 15 months of the CHAMP program (June 28th, 2020), 11,408 (8,017 patients > 40 years old) patients were followed at the CMMR, by 21 physicians, of which 90 patients had a diagnosis of HF, representing an increase of 28,6% of new diagnosis of HF during the 15 months after the launch of the program or 0.79 % of the whole clinic's patients and 4.29 HF patients/PCP. Out of 701 patients with the vulnerability code 03, 687 were aged > 40 years.

Table 1
Demographics of the Pre-CHAMP population at pre-CHAMP period and of the Overall HF population measured closest to end of the study.

Demographics	Pre-CHAMP HF population N = 70	Overall HF population N = 90
Mean age at diagnosis, yrs	67.40 ± 12.98	67.41 ± 13.70
Sex, n (%)		
Male	44 (62.9 %)	59 (65.6 %)
NYHA class, n (%)		
I	4 (5 0.7%)	5 (5.6 %)
II	13 (18.6 %)	18 (20.0 %)
III	7 (10.0 %)	7 (7.8 %)
IV	3 (4.3 %)	5 (5.6 %)
Unknown	43 (61.4 %)	55 (61.1 %)
Past cardiovascular medical history		
Number of events/procedures, n ≥ 1 (%)		
Percutaneous coronary Intervention (PCI) or Coronary artery bypass	6 (8.6 %)	4 (4.4 %)
Graft surgery (CABG)		
Implantable cardioverter-defibrillator (ICD)	0	2 (2.2 %)
Cardiac resynchronizationpacemaker (CRT)	1 (1.4 %)	1 (1.1 %)
Left ventricular assist device (LVAD)	0	0
Heart transplant	0	0
Mitraclip	0	0
Other	2 (2.9 %)	4 (4.4 %)
Type of heart failure diagnosed at clinic, n (%)		
Valvular Heart Failure	6 (8.8 %)	7 (8.0 %)
Heart Failure with preserved ejection fraction	23 (33.8 %)	30 (34.5 %)
Heart Failure with reduced ejection fraction	35 (51.5 %)	45 (51.7 %)
Atrial Fibrillation	2 (2.9 %)	3 (3.4 %)
Other	2 (2.9 %)	2 (2.3 %)
Unspecified	2 (2.9 %)	3 (3.4 %)
Median HF duration (yrs) at post-CHAMP, median (IQR)	4.45 (2.62–8.37)	3.34 (1.73–6.48)
Comorbidities, n (%)		
Atrial fibrillation	23 (32.9 %)	35 (39.3 %)
Cerebrovascular disease	5 (7.1 %)	12 (13.3 %)
Chronic obstructive pulmonary disease	20 (28.6 %)	26 (28.9 %)
Diabetes	30 (42.9 %)	42 (47.2 %)
Dyslipidemia	54 (77.1 %)	#
Hypertension	52 (74.3 %)	76 (84.4 %)
Renal disease	21 (30.0 %)	45 (50.0 %)
Smoking	16 (22.9 %)	€
Laboratory results, mean ± SD		
Sodium, (MMOL/L)	140.51 ± 2.72 (n = 47)	140.61 ± 2.71 (n = 62)
Potassium, (MMOL/L)	4.46 ± 0.45 (n = 48)	4.44 ± 0.47 (n = 64)
Blood urea, (MMOL/L)	10.10 ± 5.24 (n = 25)	9.59 ± 4.99 (n = 34)
Creatinine, (μMOL/L)	122.20 ± 55.00 (n=¥)	127.85 ± 81.97 (n = 66)
N-Terminal Pro-Brain Natriuretic Peptide (NT-ProBNP), (ρG/ML)	3929.92 ± 5610.75 (n = 49)	3210.33 ± 5193.83 (n = 15)
Brain Natriuretic Peptide (BNP), (ρG/ML)	562.33 ± 789.41 (n = 12)	519.13 ± 684.90 (n = 16)
Cardiovascular Medication, n (%)		
Beta-blockers (BB)	53 (75.7 %)	68 (75.6 %)
Mineralocorticoids receptor antagonists (MRA)	27 (38.6 %)	34 (37.8 %)
Angiotensin II receptor blockers (ARB)	19 (27.1 %)	21 (23.3 %)
Angiotensin-converting enzyme inhibitors (ACEI)	27 (38.6 %)	29 (32.2 %)
Angiotensin receptor-neprilysin inhibitors (ARNI)	7 (10.0 %)	15 (16.7 %)
Furosemide	39 (55.7 %)	54 (60.0 %)
Thiazide diuretics	9 (12.9 %)	8 (8.9 %)
Nitrates	16 (22.9 %)	29 (32.2 %)
Antiarrythmics	5 (7.1 %)	7 (7.8 %)
Platelet aggregation inhibitors (PAI)	44 (62.9 %)	58 (64.4 %)
Novel oral anticoagulants (NOAC)	19 (27.2 %)	31 (34.4 %)
Heparins	2 (2.8 %)	0
Calcium channel blockers (CCB)	16 (22.9 %)	28 (31.1 %)
Statins	46 (62.9 %)	68 (75.6 %)

#, €, ¥Missing data among laboratory results.

promising. HF patients being treated by cardiologists has been shown to have better outcomes [28,29], emphasizing the need for education of general internists and PCP. However, reports led to conflicting results, with structured educational programs demonstrating improvement in appropriate prescription and reduction in HF-related readmissions [30–32]. On the other hand, a 6-hour educational program was unsuccessful to change prescription patterns for beta-blockers, nor improved patients' quality of life [28,33]. Likewise, a cluster-randomized trial of focused educational program by Vaillant-Roussel failed to demonstrate any effect on clinical outcomes or quality of life of 241 elderly HF patients, despite a follow-up of 19 months [33]. Differences in design may explain the apparent discrepancies between these results and our findings. Indeed, our educational program was built toward the PCPs' needs, less intense but repetitive, with monthly conferences on various aspects of HF. A similar program was conducted by Bakhai et al. with internists from an academic center and 158 patients; they improved their diagnosis accuracy, triple the use of ACEI/ARB and improved outcomes in terms of emergency department visits (–32.5 %) and hospital admissions (−27.3 %) over 12 months [34].

Likewise, Murray showed that PCP deficiency to properly address the concerns of type 2 diabetes (T2D) patients on disease management impacts outcomes and could be improve by education [35]. Subsequently, Weng showed the effectiveness of a 6-month educational program for physicians to improve management of patients with T2D (BEYOND II) in approximately 50 % of participating hospitals [36]. This chronic disease program was similar to ours, with an initial face-to-face workshop followed by monthly meetings, but theirs included self-audit discussion amongst peers instead of a structured educational program.

7.4. Development of specialized HF network

Since the management of HF is difficult, many cardiovascular societies commend the development of dedicated HF networks to permit wide access to GDMT [5,6]. The Heart Failure Association (HFA) of the European Society of Cardiology (ESC) for the development of quality of care centres (QCCs) has created an accreditation for institutions that deliver HF management at different levels of care (tertiary centres, specialized HF clinics and general cardiology), to treat the entire range of HF severity in order to "unify and improve the quality of HF care, and to promote collaboration in education and research activities" [37]. Quality indicators (QIs) were therefore developed, since the traditional benchmarks were mostly limited to HF patients in advanced disease stages or cardiogenic shock whereas most patients are presenting with chronic HF. These QIs covers 5 domains of care: Structural framework, Patient assessment, Initial treatment, Therapy optimization and Assessment of patient health-related quality of life. Recently, Luedike and colleagues reported on their experience of implementing such an interdisciplinary regional approach in the Ruhr area, the largest metropolitan area in Germany and propose some components for standardization and inclusion of digital and intersectoral communication pathways as well as the need for the implementation of QIs to cover a broader spectrum of the disease [38].

While these initiatives are commendable, they focus mainly on specialized care and not on early diagnosis in the community. Consequently, the incorporation of non-cardiovascular professionals within

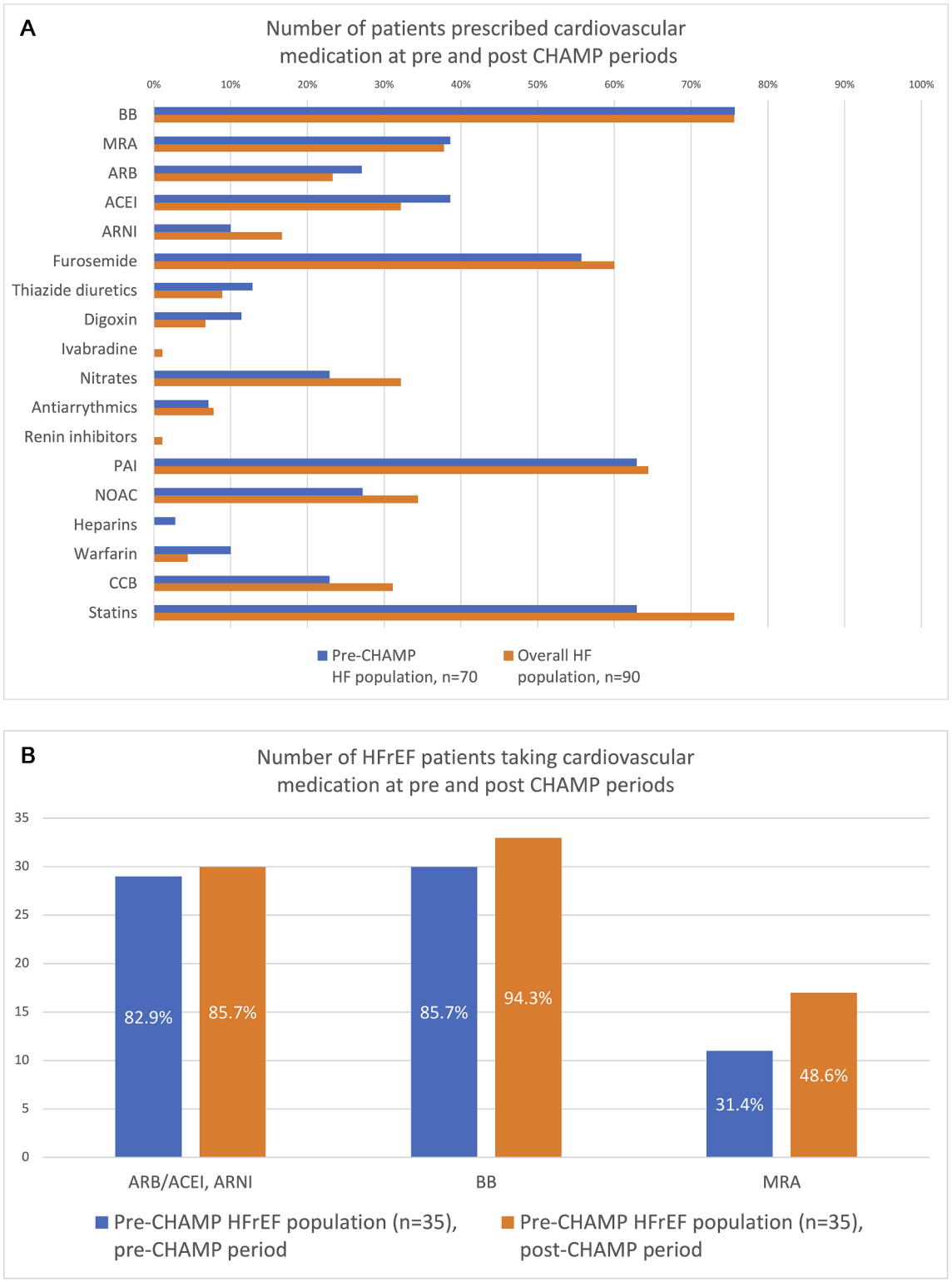
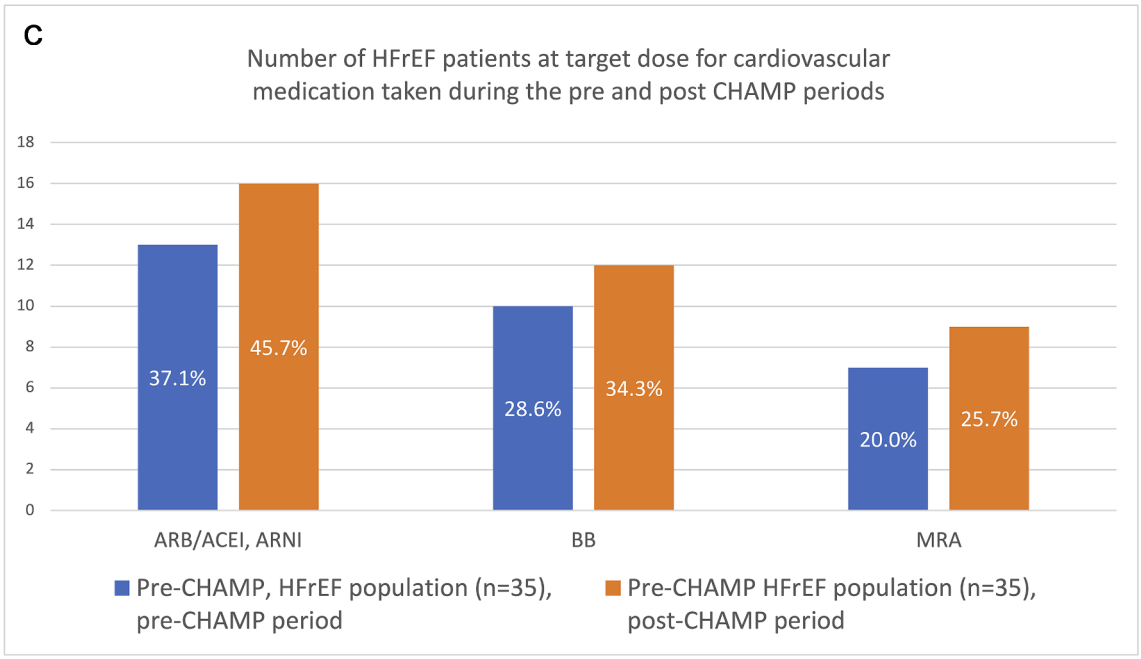


Fig. 4. Changes in medication prescribed and optimization (PRE and POST CHAMP). A. Number of patients prescribed cardiovascular medication. There was a global increase in the total number of patients treated with all classes of agents overall. B. Number of HFrEF patients taking cardiovascular medication. An increase in the number of patients treated with ARB/ACEI & ARNI (+2.8 %), BB (+8.6 %) and MRA (+17.2 %) was observed among the 35 HFrEF patients from the pre-CHAMP cohort. C. Number of HFrEF patients at target dose for cardiovascular medication. There was also an increase in the number of patients at target dose for vasodilators (+8.6 %), BB (+5.7 %) and MRA (+5.7 %) among the 35 HFrEF patients from the pre-CHAMP cohort.D. Number of HFrEF patients on tri-therapy and at target dose (PRE-CHAMP population). Amongst the 35 patients with HFrEF, the number on triple-therapy doubled from 8 (22.9 %) to 16 (45.7 %), while there was a modest increase in those at target or maximally tolerated doses from 2 (5.7 %) to 3 (8.6 %) ($p = 0.3173$). [1] $p = 0.0047$; [2] $p = 0.3173$.



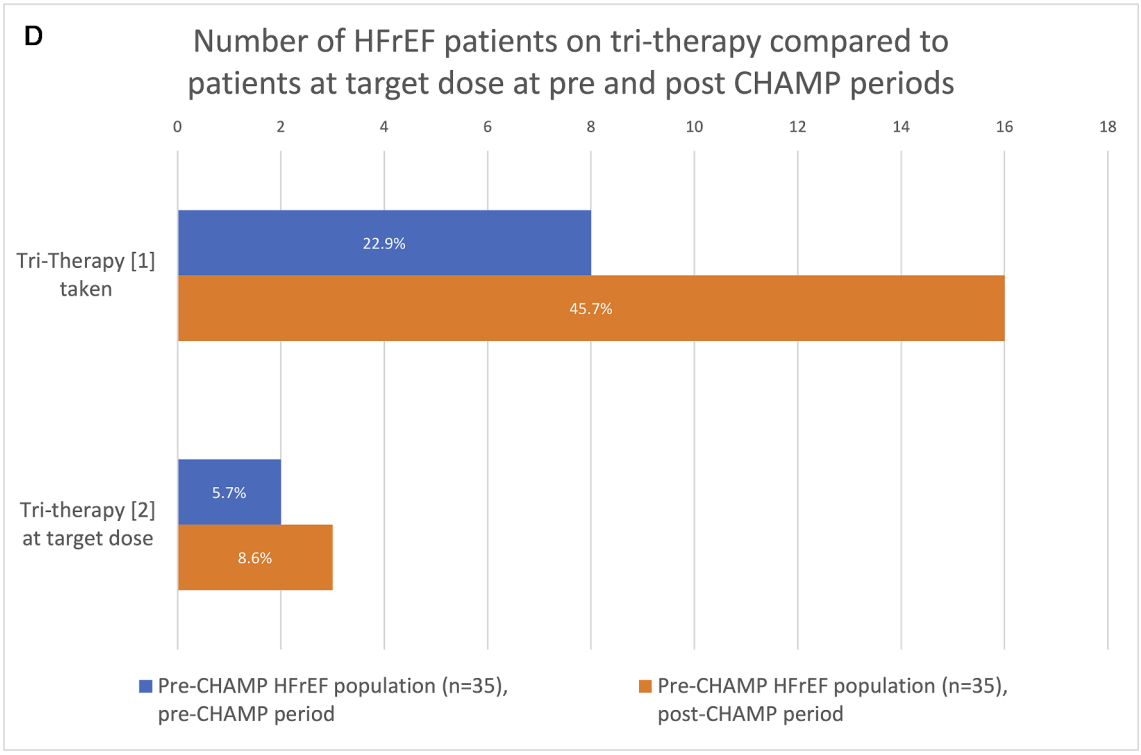


Fig. 4. (*continued*).

these networks has been at best sub-optimal and remains important as most HF patients are followed up by GPs.[39] We aimed to fill this gap by working directly with PCP in the community.

7.5. Potential impacts of the COVID-19 pandemic

On March 13th, the Quebec government declared emergency sanitary state to reduce the spread of COVID-19 [40]. An almost 80 % decrease in office visits occurred in primary care [41], for multiple reasons including avoidance of seeking health services due to patients' fear of exposure to COVID-19 [42], and shortages in individual protective equipment. CMMR was no exception to this difficult situation. Virtual care replaced in-person visits [43], representing 71.1 % of all visits during the early COVID-19 period [41], thereby creating additional challenges for HF diagnosis and management [43].

8. Limitations

Our pilot study has many limitations, including mainly the small sample size of patients and physicians involved, and the use of administrative database. Furthermore, the COVID-19 pandemic and the disruption it caused on the delivery of care may have led to fewer new

Table 2
Number of diagnosis procedures ordered during the CHAMP period per subject per procedure.

Diagnosis procedures ordered, n ≥ 1 (%)	Pre-CHAMP HF population, n = 70	Overall HF population, n = 90
All diagnosis procedures	38 (54.3 %)	37 (41.1 %)
Electrocardiogram (ECG)	13 (18.6 %)	15 (16.7 %)
Echocardiogram	21 (30.0 %)	24 (26.7 %)
Stress test	3 (4.3 %)	4 (4.4 %)
Cardiac computerized tomography (CT) scan	0	1 (1.1 %)
Cardiac magnetic resonance imaging (MRI)	2 (2.9 %)	1 (1.1 %)
Coronary angiogram	8 (11.4 %)	7 (7.8 %)
Chest X-ray	14 (20.0 %)	21 (23.3 %)
N-terminal Pro-B-type natriuretic peptide (NT-PROBNP)or B-type natriuretic peptide (BNP) dosage	18 (25.7 %)	11 (12.2 %)
Pulmonary function test - Spirometry	9 (12.9 %)	9 (10.0 %)

Table 3
Number of visits per subject per visit type or purpose/reason of visit during the CHAMP period.

Visit type, median (IQR)	Pre-CHAMP HF population, Pre-CHAMP period, n = 70	Overall HF population, CHAMP period, n = 90
All visits	3.00 (1.00–5.00)	4.00 (2.00–6.00)
Cardiovascular visits	1.00 (0.00–2.00)	1.00 (0.00–2.00)
Non-cardiovascular visits	2.00 (1.00–4.00)	3.00 (1.00–5.00)
Purpose/reason of visit, n		
Shortness of breath	60	58
Chest pain	4	11
Weakness	11	14
Peripheral edema	18	20
Palpitations	1	6
Shortness of breath, peripheral edema (swelling in legs), chest pain and/or palpitations	83	95
Other	237	441

diagnosis of HF than might have occurred in more normal times and therefore underestimate the positive impact of CHAMP reported in this pilot study.

9. Conclusion

We showed that collaboration between a specialized HF setting and a large family practice group is feasible, increase the proportion of patients diagnosed with HF and their management. We also found that PCPs follow individually a very small volume of patients with HF, which may represent an additional challenge. Nevertheless, this program increased the PCPs' confidence to diagnose and manage HF patients. Whether this strategy will improve HF diagnosis and management by PCP will be tested in a randomized-controlled trial, the Multidisciplinary Approach for high risk Patients Leading to Early diagnosis of Canadians with Heart Failure (MAPLE-CHF, NCT05859048).

CRediT authorship contribution statement

Marianne Parent: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Jacinthe Leclerc:** Data curation, Formal analysis, Methodology, Project administration, Validation. **Eileen O'Meara:** Methodology, Writing – review & editing. **Réal Barrette:** Methodology, Project administration, Resources, Writing – review & editing. **Sylvie Lévesque:** Data curation, Formal analysis, Software, Validation, Writing – review & editing. **Marie-Claude Parent:** Writing – review & editing. **Denis Brouillette:** Investigation, Writing – review & editing. **Patrick Garceau:** Conceptualization, Writing – review & editing. **Mark Liszkowski:** Investigation, Writing – review & editing. **Jean Rouleau:** Funding acquisition, Investigation, Methodology, Project administration, Writing – review & editing. **Anique Ducharme:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Physicians' survey completed at baseline and POST-CHAMP.

Categories	Questions
About you and your patients	1. Number of years as a general practitioner (GP)
	2. Is your practice mostly; rural/urban/both
	3. Practice location/locality?
	4. Approximate number of patients with HF
Diagnosis and treatment	5. There is need for better access to echocardiography?
	6. There is need for better access to echocardiography locally?
	7. Do you have access to Brain Natriuretic Peptide measurement (BNP)?
	8. Do you use Brain Natriuretic Peptide measurement (BNP)?
	9. Would you like access to BNP?
	10. Do you refer all new heart failure patients to hospital?
Guidelines	11. Have you read the CCS or AHA heart failure guidelines?
	12. These guidelines have influenced your management of CHF patients.

(*continued on next page*)

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Categories	Questions
	13. I am confident about treating patients with heart failure
	14. I am confident about **initiating** the following drugs in patients with heart failure (ACEI, ARB, Beta-blockers, Diuretics, MRA, Digoxin, Ivabradine, Sacubitril/valsartan)
	15. I am confident about **dose titration** of the following drugs in patients with heart failure (ACEI, ARB, Beta-blockers, Diuretics, MRA, Digoxin, Ivabradine, Sacubitril/valsartan)
Training and Education	16. Would specific education on heart failure management from CHAMP be useful for a. GPs? b. Nurses? c. Other health care professionals (specify)?
	17. How could training be best delivered? a. Posters on HF diagnosis and management b. Preceptorships from interdisciplinary specialists c. Lunch and learn d. Education and reference tools e. Individualized patient-management questions with interdisciplinary specialists
Future of CHAMP	18. There is a need for a partnership between interdisciplinary HF specialists and GP.
	19. CHAMP will help to increase compliance to guidelines.
	20. There is a need for a referral pattern between GP and interdisciplinary HF specialist.
	21. Access to CHAMP could improve patient care?
	22. Access to CHAMP could reduce hospital admissions?
Post-CHAMP appreciation	23. Have you used the CHAMP?
	24. Did you find the program useful?
	25. Was the advice given what you wanted/expected
	26. Was communication between interdisciplinary HF specialists from CHAMP and GP appropriate?
	27. Did the CHAMP help you?
	28. Do you feel the implementation of CHAMP went well?

Appendix B

Vulnerability codes	Description
1	Chronic and recurrent mental health issues (DSM-V): generalized anxiety disorders, eating disorders (anorexia, bulimia)
2	Chronic obstructive pulmonary diseases (COPD), moderate to severe asthma (patient who has shown an FEV1 less than 70 % of the predicted value), occupational lung diseases
3	Arteriosclerotic heart disease (MCAS), heart failure, severe hypertension (grade 3)
4	Cancer associated with past, present, or planned systemic chemotherapy or radiotherapy or in the palliative phase
5	Diabetes with hemoglobin A1C of 6.5 or more at diagnosis excluding gestational diabetes
6	Drug addiction or alcoholism undergoing withdrawal or having led to hard drug or alcohol detoxification in the last five years, addiction under methadone or buprenorphine treatment
7	HIV/AIDS, hepatitis C
8	Degenerative diseases of the nervous system, dementia with MMSE of 26 or less, spinal cord injuries with permanent sequelae leading to disability and head injuries with permanent sequelae leading to disability
9	Chronic inflammatory diseases: rheumatoid arthritis, psoriasis with non-skin involvement, lupus, scleroderma and other collagenoses, ulcerative colitis, Crohn's disease
10	Acute major depressive disorders, first episode or acute anxiety disorders, first episode
11	Recurrent major depressive disorders
12	Chronic kidney failure with creatinine clearance less than 30 ml per minute, liver failure
13	Thrombogenic diseases requiring lifelong anticoagulation, atrial fibrillation with CHADS of 2 and above
14	–
15	Attention deficit disorders with or without hyperactivity for patients under 18 years of age
16	Intellectual disability for patients with significant expression and comprehension disorders
17	Hearing impairment when communication with the patient is gestural or written, and visual impairment requiring the presence of an attendant during the patient's meeting with the doctor
18	Chronic pain persisting for more than six (6) months related to a chronic condition and causing functional incapacity or requiring the continuous intake of prescription medication to be functional
19	Cerebrovascular accident resulting in severe mobility, behavior, expression, or comprehension disorders
20	Mental health issues (DSM-IV): psychotic disorders, bipolar disorders, pervasive developmental disorders (autism spectrum disorders, Asperger's), panic disorder

Source: Régie de l'assurance maladie du Québec, RAMQ: https://www.ramq.gouv.qc.ca/fr/Pages/resultats-recherche.aspx?k=code+vuln%c3%a9rabilit%c3%a9.

Appendix C

List of data collected from HF patients at CMMR.

Data
Demographics: date of birth, gender, and NYHA class;
Concomitant diseases; past cardiovascular history
Comorbidities; AF, cerebrovascular disease, COPD, diabetes, dyslipidemia, hypertension, renal disease, smoking
Diagnostic Test performed to diagnose HF (invasive, functional, imaging, BNP/NT-proBNP, electrolytes, creatinine, blood urea);
Type of HF (valvular, HF with preserved or reduced ejection fraction);
Date and reason of Visits; cardiovascular, non-cardiovascular
Resources used at each visit (nurse, doctor, pharmacist, dietician or other);
Cardiovascular medications (name, doses, frequency) prescribed, including reasons for change in doses;
Procedures performed to treat HF.

Appendix D

List of topics covered through Luncheon conferences at the CMMR.

1. Heart failure: overview
2. Heart failure: extent of the problem and physiopathology
3. Pharmacological approach to treat HF
4. Diagnostic modalities for HF
5. Case study: breathless patients
6. Less common heart disease: amyloidosis
7. Non-pharmacological treatment for HF
8. Advanced HF: how to recognize it?
9. HF with preserved systolic function: how to navigate
10. Summary – Put it all together

Appendix E. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcha.2023.101330.

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