A Population-Based Study to Evaluate the Effectiveness of Multi-Disciplinary Heart Failure Clinics and Identify Important Service Components

Wijeysundera et al: Effectiveness of Heart Failure Clinics

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Abstract

Background—Multi-disciplinary heart failure (HF) clinics are efficacious in clinical trials. Our objectives were to compare real-world outcomes of HF patients treated in HF clinics vs. usual therapy and identify HF clinic features associated with improved outcomes.

Methods and Results—The service components at all HF clinics in Ontario, Canada were quantified using a validated instrument and categorized as high/medium/low intensity. We used propensity-scores to match HF clinic and control patients discharged alive after a HF readmission in 2006-07. Outcomes were mortality, and both all-cause and HF readmission. Cox-proportional hazard models were used to evaluate HF clinic level characteristics associated with improved outcomes. We identified 14,468 HF patients, of whom 1,288 were seen in HF clinics. With 4 years of follow-up, 52.1% of HF clinic patients died versus 54.7% of control patients (p-value 0.02). HF clinic patients had increased readmissions (87.4% vs. 86.6% for all-cause [p-value 0.009]; 58.7% vs. 47.3% for HF-related [p-value <0.001]). There was no difference between high, medium or low intensity clinics in terms of mortality, all-cause or HF readmissions. HF Clinics with greater frequency of visits (> 4 contacts of significant duration over 6 months) were associated with lower mortality (HR 0.14; p-value <0.0001) and hospitalization (HR 0.69; p-value 0.039). More intensive medication management was associated with lower all-cause (HR 0.46; p-value <0.001) and HF readmission (HR 0.42; p-value <0.001).

Conclusions—In this real-world population based study, we found that multi-disciplinary HF clinics are associated with a decrease in mortality but increase in readmissions.

Key Words: heart failure, health outcomes, multi-disciplinary clinic
Heart failure (HF) is a complex, progressive syndrome characterized by abnormal heart function resulting in reductions in both quality of life and survival.\(^1\) Health care delivery models aimed at better control of heart failure have therefore been of particular interest.\(^2\)

Disease management through multi-disciplinary community care clinics improves patient outcomes in multiple health conditions.\(^3,4\) Randomized studies have evaluated the efficacy of such clinics in HF with some suggesting that mortality is decreased.\(^1,2,5\) An important limitation is the substantial heterogeneity in both the composition of the HF clinics studied, and the interventions offered. Moreover, there remains uncertainty about which components of specialized HF clinics are most important. For example, are beneficial effects mediated through more aggressive medication titration, or through enhanced surveillance?

Our objective was to address these important gaps in knowledge through a field evaluation, whereby we assessed real world practice for HF patients in Ontario, Canada. Our specific aims were i) to compare clinical effectiveness for the cohort of Ontario patients treated at specialized HF clinics to a cohort of HF patients treated with usual care and ii) identify which characteristics of HF clinic service models were associated with improved outcomes.

**Methods**

This study was approved by the Institutional Research Ethics Board at Sunnybrook Health Sciences Centre, University of Toronto.

**Data Sources**

Ontario, which is Canada’s most populous province, has more than 13 million residents who have universal access to physician and hospital services through a publicly funded healthcare
program. Population-level administrative databases with information on all Ontario residents are available at the Institute for Clinical Evaluative Sciences (ICES). These databases were linked using encrypted unique patient identifiers thereby protecting patient confidentiality, while allowing for the longitudinal evaluation of clinical outcomes. The Canadian Institute for Health Information discharge abstract database (CIHI-DAD) contains data on all hospitalizations in the province. The CIHI-DAD record includes a ‘most responsible’ diagnosis and up to 24 additional diagnoses codes that can be used to estimate co-morbidity. The Ontario Registered Persons Database was used to ascertain mortality. Data on physician visits/consultations were obtained from the fee-for-service claims history in Ontario Health Insurance program (OHIP) database.

Study Design and Sample

We performed a cohort study of patients discharged alive after a HF hospitalization from April 1st, 2006 to March 31st 2007, comparing patients treated in HF clinics to a matched control cohort not treated in HF clinics. Patients were identified based on International Classification of Disease (ICD) Version 10 code I50, as the most responsible diagnosis in the CIHI-DAD. We included all patients older than 20 years who were Ontario residents with valid health insurance numbers. If a patient had more than one HF hospitalization over this period, the first hospitalization was selected as the index event.

We categorized patients as HF clinic patients based on the presence of an OHIP claim for HF by one of 91 identified HF clinic physicians in Ontario, occurring after hospital discharge and within 1 year of the index event. HF clinic physicians were identified in an environmental scan of HF clinics across Ontario conducted by our group. In this previous study, HF clinics were defined as a clinic consisting of a minimum of a physician and a nurse, one of whom had specialized training/interest in HF. Once identified, interviews were conducted at the HF clinic,
in order to confirm that they met this definition, and to evaluate the service components of the clinic. Any patient who was not seen by a HF clinic patient was categorized as a control patient. Control patients received usual care which may have been no follow-up at all, or follow-up with a family physician, internist, or cardiologist.

We used a validated instrument, the HF Disease Management Scoring Instrument (HF-DMSI), to score the intensity of each HF clinic across 10 categories (see Appendix 1). Because the HF-DMSI does not provide an overall score, it is not possible to rank clinics based on this alone. Therefore, we performed a concept mapping exercise, using a HF expert panel. The expert panel determined the relative importance of each of the 10 categories of the HF-DMSI, and then using this implicit weighting, categorized the clinics into three intensity strata (high, medium, and low).

Of the 91 HF clinic physicians in practice in 2006-2007 in Ontario, 74 (81%) consented to having their OHIP billing numbers used for this study. To mitigate potential misclassification bias, we excluded patients discharged from the 6 hospitals in which the non-consenting HF clinic physicians practised.

Outcomes
Outcomes were evaluated until March 31st, 2010. The primary effectiveness outcome was all-cause mortality. Secondary outcomes were all-cause readmission, and hospitalization for HF.

Statistical Analyses
Given the observational nature of our study, we used propensity score methods to account for anticipated differences between HF clinic and non-HF clinic cohorts. Propensity score methods are an analytical approach to minimize the effect of measured confounding factors. We fitted a multivariable logistic regression model, where the exposure was having been seen by a HF clinic.
clinic physician (see Appendix 2).\textsuperscript{13} We used this model to calculate a propensity score of the predicted probability of being in a HF clinic. We then created a propensity-score–matched cohort by matching each patient in the HF clinic cohort with one in the control cohort (a 1:1 match).\textsuperscript{9, 10} A greedy nearest-neighbour–matching algorithm was used to match each HF clinic patient to the “nearest” control patient on the basis of the logit of their propensity score, with matching occurring if the difference in the logit was less than 0.2 times the standard deviation of the scores (the calliper width).\textsuperscript{9, 10} Standardized differences of the mean (< 0.1) were used to indicate good balance in the matched sample.\textsuperscript{10, 14}

Kaplan-Meier survival curves for each primary and secondary outcome were estimated for the matched HF clinic and control cohorts, initiated at the time of discharge from the index hospitalization.\textsuperscript{10} Differences between survival curves were compared using the stratified log-rank test to account for the matched nature of the sample.\textsuperscript{10, 13, 16}

To explore the characteristics of HF clinics that were associated with improved outcomes, Cox-proportional hazard models were developed, restricted to the entire HF clinic population. The unit of analysis for these models was the patient. Robust variance estimates were obtained to account for the clustering of patients within HF clinics. We created separate models with all-cause mortality, all-cause readmission and HF readmission as the dependent variable. In order to adjust for patient-level co-morbidities, we used the variables described for the hierarchical regression model developed by Krumholz and colleagues for HF patients using Medicare claims data (see Appendix 3).\textsuperscript{17}

After adjustment for patient-level co-morbidities, clinic level co-variates were forced into the regression. Due to concerns about the possibility of multicollinearity, the effects of the scores on the HF-DMSI instrument, and the clinic intensity strata were estimated in separate
models. The final model included only HF-DMSI categories that were statistically significant when evaluated individually.

**Sensitivity Analyses**

**LV function**

Studies show that HF patients with preserved left ventricular (LV) function (i.e. LV function > 45%) have improved survival compared to patients with reduced LV function. LV function data are not available in administrative databases. Propensity score methods may not necessarily balance all unmeasured confounders. To test the degree to which our propensity match balanced LV function between HF clinic and control patients, we repeated the above propensity score in a separate cohort of 9,943 patients from the Enhanced Feedback for Effective Cardiac Treatment (EFFECT) study, which contained both administrative data and clinical data on LV function.

**Survivorship Bias**

Our HF clinic definition required survival until assessment by a HF clinic physician. We performed three sensitivity analyses to evaluate the impact of survivorship bias. We did two landmark analyses, restricting our analysis to patients who survived at least i) 30 days and ii) 1 year after discharge. We also performed an analysis whereby we used the date of being seen by a HF clinic physician as the start date for each HF clinic patient. We randomly assigned start dates to control patients, such that the distribution of the interval between index hospital discharge and start date was identical for both cohorts. We excluded any control patient who died prior to their assigned start date, and then repeated the propensity match.

All analyses were performed using SAS Version 9.2 (SAS Institute).
Results

Study Sample

From April 2006 to March 2007, 16,300 patients were admitted to hospital in Ontario with a primary diagnosis of HF. When restricted to patients over the age of 20, with valid Ontario health card numbers and to patients who survived until discharge, our sample size was 14,468. Of these patients, 1,288 were seen by HF clinic physicians within 1 year of their index discharge, with 10,996 control patients (Figure 1). Among the HF clinic patients, there was a substantial range in the frequency of HF clinic physician visits as compared to other non-HF clinic physicians. On average, HF clinic visits represented 15% of all physician visits (median 9.2%, intra-quartile range 2.7%-21.3%).

Of the 14,468 patients alive after discharge, 2,184 patients were excluded (13% of overall group) because they were discharged from institutions with incomplete HF physician billing data, and therefore could not be accurately classified.

Baseline Characteristics

Prior to matching, these two cohorts were substantially different (see Table 1). Patients in HF clinics tended to be younger, with a mean age of 71.8 years (standard deviation [SD] 13.4), compared to 77.0 years (SD 11.5) for control patients. More males (60.1% vs. 47.9%) were seen in HF clinics compared to control. There were substantial differences in residence and socioeconomic status, with more urban (92.5% vs. 80.9%) and higher income patients in HF clinics. In general, control patients had more co-morbidities. In Appendix 2, the components of the propensity score used to match HF clinic and control patients are detailed. We found that older patients were less likely to be seen in HF clinic (odds ratios [OR] 0.969 for each year increase in age (p-value <0.0001), while males were more likely to referred to HF clinic (OR
1.34, p-value <0.0001). The strongest predictor of being seen in a HF clinic was geographic region with OR in the 50-150 range depending on region, suggesting that regional inequality in access was a major driver for why patients were not seen in clinic.

In Table 2, the baseline characteristics of HF clinic and control patients after propensity matching is shown. All 1,288 HF patients were successfully matched to control patients. There was good balance between the two groups with standardized differences less than 0.1. There was complete follow-up until March 31st, 2010 for all patients.

**Clinical Outcomes**

Over the 4 years of follow-up, all-cause mortality was 52.1% in the HF clinic cohorts compared to 54.7% in the control group, which was statistically significant, with a p-value of 0.02 (Figure 2). In contrast, the HF clinic group had greater rates of both all-cause readmission (87.4% vs. 86.6%; p-value 0.009) and HF readmission (58.7% vs. 47.3%; p-value <0.001) in comparison to the control patients.

**HF Clinic Characteristic Associated with Improved Outcome**

The 1,288 HF clinic patients were seen at 21 HF clinics, of which 8 were classified as high intensity clinics, 8 medium intensity clinics and 5 as low intensity clinics. The intensity scores of these clinics based on the HF-DMSI are summarized in Appendix 4. We did not find any statistically significant relationship between HF clinic intensity strata and mortality or all-cause/HF readmission (see Appendix 5).

The relationship of these clinic level scores on the HF-DMSI and outcomes is shown in Table 3. Higher complexity clinics, with greater than 4 contacts between providers and patients had a significant reduction in mortality (HR 0.14; 95% CI 0.08-0.25; p-value <0.001) compared to clinics with only a single contact with little or no follow-up.
A more intensive medication management program was associated with reduced all cause and HF readmission (HR 0.46 and HR 0.42 respectively). Higher complexity clinics with greater than 4 provider-patient contacts were also associated with a reduction in hospitalization (HR 0.69; p-value 0.039). However, greater involvement of caregivers, or a more comprehensive education program on supporting self care was associated with increased hospitalization (Table 3).

**Sensitivity Analyses**

*Quality of matching between HF clinic patients and control patients*

When the matching algorithm was applied to the EFFECT study cohort, there was some imbalance in LV function between HF clinic patients and control patients (Appendix 6). The proportion of patients with preserved LVEF was higher in the control group than in the HF clinic group (22.5% vs. 16.7%).

*Survivorship Bias*

These results are found in Appendix 7. In all three analyses, there was no statistically significant difference between survival in the HF clinic group and the control group. However, the findings for hospitalization were robust.

**Discussion**

In this population-based comparison of HF patients treated at specialized HF clinics versus control, we found that only approximately 10% of HF patients were seen at specialized HF clinics after hospital discharge. Treatment at HF clinics was associated with a small but statistically significant reduction in mortality, but increased all-cause and HF readmissions.
HF clinics have been studied extensively in the literature as a preferred mode of ambulatory care delivery to patients with this complex condition. Despite this, our study showed that a minority of patients are actually treated in HF clinics. Indeed, our analysis found substantial regional differences in access, with patients in different regions having a 150-fold difference in being treated in HF clinics. This is consistent with our previous environmental scan that showed large geographic disparities in the number of clinics per capita.\textsuperscript{7}

Meta-analyses of randomized controlled trials have generally shown that these clinics are associated with an improvement in mortality, with most showing an improvement in hospitalization when compared to control.\textsuperscript{1, 2, 5, 19-33} We found similar improvements in mortality, albeit of a smaller magnitude.\textsuperscript{2, 27} It is important to note the potential for survivorship bias in our study. The survival curves for the HF clinic and control patients separated early, and in our sensitivity analyses, this mortality difference was no longer significant. It is reassuring that previous investigators evaluating specialist care for HF patients, using a time-varying co-variate design to account for survivorship bias, have found similar mortality findings.\textsuperscript{34} Nonetheless, given these limitations, readers should exercise caution in interpreting the mortality differences we observed.

In contrast, the findings on hospitalization were robust in all analyses. Unlike other trials, we found an increase in hospitalizations\textsuperscript{27}. There are several potential explanations for our findings. Ours is an observational study; although we used advanced statistical methods to mitigate this, persistent confounding is likely to remain, because we were limited to data contained in administrative databases, and did not have access to other important clinical variables, such as LV function and symptom severity that have important impact on clinical decision making and prognosis.\textsuperscript{9}
Most importantly, the clinics in Ontario may not be representative of those evaluated in clinical trials. Indeed, in our previous work, we found a wide spectrum of service models in Ontario. Notably, the identified HF clinics were principally focused on outpatient care, with no in-hospital or home-based components. Several studies suggest that hospital discharge planning, and a home-based intervention may be critical components necessary to reduce hospitalizations.27, 35

The large sample size of our study affords the opportunity to evaluate the association between clinic-level characteristics and outcomes. We found that the most important clinic level characteristic was the frequency and complexity of provider-patient contact. Of note, intensity of medication management, and the comprehensiveness of the education program did not appear to be a significant factor in reducing mortality, although medication management reduced hospitalization.

This finding is contrary to some of the prevailing hypotheses regarding the mechanism of benefit of HF clinics which suggest that HF clinics principally improve medication utilization and compliance. Instead, our results suggest, through involvement of the caregiver and improved education, there is better surveillance and the potential for earlier intervention. In this analysis, care-giver involvement, in addition to more comprehensive education was associated with more hospitalization, suggesting that the greater screening leads to earlier intervention that appears to be hospital based. This is similar to work from other investigators, which has shown that greater access to outpatient primary care is associated with increased hospitalization36, 37.

These counter-intuitive findings provide new insight into the care of these patients in Ontario. They suggest that the mortality benefit afforded by HF clinics may be mediated in part by earlier hospitalization and intervention, and thus avoidance of critical deterioration. In this
setting, one can argue that these hospitalizations are not avoidable, but maybe an important mediator of improved survival. Balanced against this are the substantial cost implications of the higher HF readmission rates among HF clinic patients, which may impact the cost-effectiveness of this mode of ambulatory care delivery. Our group has previously evaluated this issue using literature estimates to model the costs and outcomes for heart failure clinic patients. Based on these estimates from randomized trials, which showed a statistically significant survival benefit associated with HF clinics, but a non-significant trend towards increased hospitalization, we concluded that HF clinics were a cost-effective intervention. Repeating these analyses using the real world estimates from our current study is an area of active research for our group.

Our study must be interpreted in the context of several limitations that merit discussion. First, as elaborated, there is the possibility of survivorship bias. Second, we did not have information on LV function. Moreover, based on the EFFECT analysis, LV function was likely not balanced. However, patients with preserved LV tend to have improved survival; as such, we are likely underestimating the survival benefit afforded by HF clinics. In addition, we did not have access to other clinically important variables such as patient education status, and HF symptom severity, as quantified by New York Heart Association (NYHA) severity. Finally, we classified HF clinic patients using physician billing numbers, assuming that all HF patients seen by a HF clinic physician are seen in a HF clinic. This may not be true; nonetheless, it is likely that the care provided by a HF clinic physician to HF patients seen outside of a formal HF clinic is comparable to those in the HF clinic. In addition, any error introduced by potential misclassification of non-HF clinic patients would result in a bias towards the null, suggesting that we are underestimating the true effect of HF clinics.
In conclusion, we found that HF clinics are associated with an increase in re-
hospitalizations, most notably HF readmissions. There is a complex relationship between the
complexity of HF clinic services and health outcomes; this is highly relevant to policy makers
and clinicians when designing such clinics.

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Disclosures

The authors have no relevant conflicts to disclose. Dr Wijeysundera had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References


6. Jacobs P YR. Using Canadian administrative databases to derive economic data for health technology assessments. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2009.


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<th>Region</th>
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<th>Non-HF clinic</th>
<th>p-p-value</th>
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<td>N=10,996</td>
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<td>77.01 ± 11.47</td>
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<td>46 (0.4%)</td>
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<td>863 (7.8%)</td>
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<td>Old myocardial infarction</td>
<td>628 (48.8%)</td>
<td>4,462 (40.6%)</td>
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<td>3,064 (27.9%)</td>
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<td>781 (7.1%)</td>
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Charlson Comorbidity Index

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<td>2-3</td>
<td>260 (20.2%)</td>
<td>2,193 (19.9%)</td>
</tr>
<tr>
<td>3-5</td>
<td>329 (25.5%)</td>
<td>2,814 (25.6%)</td>
</tr>
<tr>
<td>&gt; 5</td>
<td>160 (12.4%)</td>
<td>1,593 (14.5%)</td>
</tr>
</tbody>
</table>

Adjusted Clinical Group (ACG)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=3</td>
<td>440 (34.2%)</td>
<td>3,573 (32.5%)</td>
</tr>
<tr>
<td>3-5</td>
<td>313 (24.3%)</td>
<td>2,659 (24.2%)</td>
</tr>
<tr>
<td>5-8</td>
<td>314 (24.4%)</td>
<td>2,805 (25.5%)</td>
</tr>
<tr>
<td>&gt; 9</td>
<td>221 (17.2%)</td>
<td>1,959 (17.8%)</td>
</tr>
</tbody>
</table>
Table 2. Baseline Characteristics of Matched Cohort

<table>
<thead>
<tr>
<th></th>
<th>HF Clinic</th>
<th>Non-HF Clinic</th>
<th>Standardized difference (matched sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1,288</td>
<td>1,288</td>
<td></td>
</tr>
<tr>
<td>Age (years, Mean ± SD)</td>
<td>71.80 ± 13.35</td>
<td>71.65 ± 13.29</td>
<td>0.01</td>
</tr>
<tr>
<td>Male, N(%)</td>
<td>774 (60.1%)</td>
<td>823 (63.9%)</td>
<td>0.08</td>
</tr>
<tr>
<td>Missing</td>
<td>7 (0.5%)</td>
<td>10 (0.8%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Erie St. Clair</td>
<td>9 (0.7%)</td>
<td>6 (0.5%)</td>
<td>0.03</td>
</tr>
<tr>
<td>South West</td>
<td>19 (1.5%)</td>
<td>25 (1.9%)</td>
<td>0.04</td>
</tr>
<tr>
<td>Waterloo Wellington</td>
<td>99 (7.7%)</td>
<td>103 (8.0%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Hamilton Niagara</td>
<td>154 (12.0%)</td>
<td>168 (13.0%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Haldimand Brant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central West</td>
<td>45 (3.5%)</td>
<td>50 (3.9%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Mississauga Halton</td>
<td>102 (7.9%)</td>
<td>86 (6.7%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Toronto Central</td>
<td>165 (12.8%)</td>
<td>168 (13.0%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Central</td>
<td>177 (13.7%)</td>
<td>170 (13.2%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Central East</td>
<td>205 (15.9%)</td>
<td>198 (15.4%)</td>
<td>0.01</td>
</tr>
<tr>
<td>South East</td>
<td>27 (2.1%)</td>
<td>31 (2.4%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Champlain</td>
<td>192 (14.9%)</td>
<td>203 (15.8%)</td>
<td>0.02</td>
</tr>
<tr>
<td>North Simcoe Muskoka</td>
<td>71 (5.5%)</td>
<td>61 (4.7%)</td>
<td>0.04</td>
</tr>
<tr>
<td>Location</td>
<td>North East</td>
<td>North West</td>
<td>P-value</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>15 (1.2%)</td>
<td>9 (0.7%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Rural</td>
<td>95 (7.4%)</td>
<td>102 (7.9%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Urban</td>
<td>1,192 (92.5%)</td>
<td>1,185 (92.0%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Unknown</td>
<td>&lt;6 (0.1%)</td>
<td>1 (0.1%)</td>
<td>0</td>
</tr>
</tbody>
</table>

**Neighbourhood Income Equivalent**

<table>
<thead>
<tr>
<th>Equivalent</th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>272 (21.1%)</td>
<td>283 (22.0%)</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>277 (21.5%)</td>
<td>281 (21.8%)</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>225 (17.5%)</td>
<td>223 (17.3%)</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>252 (19.6%)</td>
<td>256 (19.9%)</td>
<td>0.01</td>
</tr>
<tr>
<td>5</td>
<td>256 (19.9%)</td>
<td>239 (18.6%)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Coronary artery disease**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>717 (55.7%)</td>
<td>734 (57.0%)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Old myocardial infarction**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>628 (48.8%)</td>
<td>613 (47.6%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Diabetes mellitus**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>649 (50.4%)</td>
<td>662 (51.4%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Hypertension**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,068 (82.9%)</td>
<td>1,039 (80.7%)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

**Cerebrovascular disease**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80 (6.2%)</td>
<td>74 (5.7%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

(Yes/No)

**Chronic cerebrovascular disease**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23 (1.8%)</td>
<td>25 (1.9%)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Chronic renal insufficiency**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>313 (24.3%)</td>
<td>323 (25.1%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Chronic pulmonary disease**

<table>
<thead>
<tr>
<th></th>
<th>North East</th>
<th>North West</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>275 (21.4%)</td>
<td>276 (21.4%)</td>
<td>0</td>
</tr>
<tr>
<td>Condition</td>
<td>Count 1 (%)</td>
<td>Count 2 (%)</td>
<td>P value</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>Dementia</td>
<td>43 (3.3%)</td>
<td>46 (3.6%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Malignancy</td>
<td>76 (5.9%)</td>
<td>83 (6.4%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Charlson Comorbidity Index**

<table>
<thead>
<tr>
<th>Index</th>
<th>Count 1 (%)</th>
<th>Count 2 (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=2</td>
<td>539 (41.8%)</td>
<td>517 (40.1%)</td>
<td>0.03</td>
</tr>
<tr>
<td>2-3</td>
<td>260 (20.2%)</td>
<td>261 (20.3%)</td>
<td>0</td>
</tr>
<tr>
<td>3-5</td>
<td>329 (25.5%)</td>
<td>354 (27.5%)</td>
<td>0.04</td>
</tr>
<tr>
<td>&gt; 5</td>
<td>160 (12.4%)</td>
<td>156 (12.1%)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Adjusted Clinical Group (ACG)**

<table>
<thead>
<tr>
<th>ACG</th>
<th>Count 1 (%)</th>
<th>Count 2 (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=3</td>
<td>440 (34.2%)</td>
<td>447 (34.7%)</td>
<td>0.01</td>
</tr>
<tr>
<td>3-5</td>
<td>313 (24.3%)</td>
<td>324 (25.2%)</td>
<td>0.02</td>
</tr>
<tr>
<td>5-8</td>
<td>314 (24.4%)</td>
<td>317 (24.6%)</td>
<td>0.01</td>
</tr>
<tr>
<td>&gt; 9</td>
<td>221 (17.2%)</td>
<td>200 (15.5%)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

HF heart failure;
## Table 3. Clinic Level Predictors of Outcome

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DEATH</th>
<th>HF READMISSION</th>
<th>ALL-CAUSE READMISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI)</td>
<td>P-value</td>
<td>HR (95% CI)</td>
</tr>
<tr>
<td>Recipient (high values mean greater involvement of the caregiver in addition to the patient)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>3</td>
<td>1.15(0.93,1.42)</td>
<td>0.20</td>
<td>1.17(0.94,1.44)</td>
</tr>
<tr>
<td>4</td>
<td>1.09(0.90,1.31)</td>
<td>0.38</td>
<td>1.44(0.92,2.25)</td>
</tr>
<tr>
<td>Education and counseling aimed at supporting self-care (higher values mean more education/counseling)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>2</td>
<td>1.42(0.86,2.34)</td>
<td>0.17</td>
<td>2.86(1.25,6.55)</td>
</tr>
<tr>
<td>3</td>
<td>1.07(0.78,1.48)</td>
<td>0.66</td>
<td>1.84(1.19,2.84)</td>
</tr>
<tr>
<td>4</td>
<td>1.40(0.88,2.23)</td>
<td>0.15</td>
<td>2.61(1.51,4.53)</td>
</tr>
<tr>
<td>Medication management (higher values mean greater intensity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>3</td>
<td>0.83(0.62,1.08)</td>
<td>0.16</td>
<td>0.42(0.26,0.65)</td>
</tr>
</tbody>
</table>
HR: hazard ratio; HF: heart failure; please see Appendix 1 for definitions of scores on clinic level characteristics. Please see Appendix 3 for individual level covariates which were adjusted for

<table>
<thead>
<tr>
<th></th>
<th>Social support (high values mean greater peer support available)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>1</td>
<td>0.79(0.68,0.93)</td>
<td>0.005</td>
<td>0.72(0.64,1.06)</td>
<td>0.002</td>
</tr>
<tr>
<td>2</td>
<td>0.97(0.85,1.10)</td>
<td>0.67</td>
<td>0.92(0.80,1.06)</td>
<td>0.246</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Frequency of Follow-Up (higher values mean greater frequency)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>2</td>
<td>0.14(0.07,0.25)</td>
<td>&lt;0.001</td>
<td>1.34(0.608,2.99)</td>
<td>0.47</td>
</tr>
<tr>
<td>3</td>
<td>0.14(0.08,0.25)</td>
<td>&lt;0.001</td>
<td>1.14(0.68,1.88)</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Figure Legends

Figure 1. Study Patient Selection: HF - health failure

Figure 2. Outcomes in Propensity-Matched HF Clinic and Control Patients
Figure 1: Patient Selection

- # of unique inpatient hospitalizations for HF in fiscal 2006 N=16300

  - Restricted to age > 20 years
    - N=16259

  - Restrict to valid healthcare number and alive after the index discharge
    - N=14,468

- 1,288 HF clinic patients based on billing numbers

- 2,184 patients excluded because from incomplete billing data institution

- 10,996 standard care patients
Figure 2: Outcomes in Propensity-Matched HF Clinic and Control Patients

KM curves in PS-Matched sample: Time to death

KM curves in PS-matched sample: Time to HF readmission

KM curves in PS-matched sample: Time to all cause readmission

p-value 0.02

p-value 0.009

p-value <0.001
A Population-Based Study to Evaluate the Effectiveness of Multi-Disciplinary Heart Failure Clinics and Identify Important Service Components

Harindra C. Wijeysundera, Gina Trubiani, Xuesong Wang, Nicholas Mitsakakis, Peter C. Austin, Dennis T. Ko, Douglas S. Lee, Jack V. Tu and Murray Krahn

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Data Supplement (unedited) at:
http://circheartfailure.ahajournals.org/content/suppl/2012/12/10/CIRCHEARTFAILURE.112.971051.DC1

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http://circheartfailure.ahajournals.org/subscriptions/
Appendix 1: Description of Heart Failure Disease Management Scoring Instrument

<table>
<thead>
<tr>
<th>Intervention category</th>
<th>Points to be assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recipient</strong></td>
<td>1=Provider alone</td>
</tr>
<tr>
<td></td>
<td>2=Patient alone</td>
</tr>
<tr>
<td></td>
<td>3=Patient with some inclusion of caregiver</td>
</tr>
<tr>
<td></td>
<td>4=Patient with a caregiver who is central to the intervention</td>
</tr>
<tr>
<td><strong>Intervention content</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Education and counselling aimed at supporting self-care</strong></td>
<td>0=No mention of education</td>
</tr>
<tr>
<td></td>
<td>1=Focus solely on importance of treatment adherence</td>
</tr>
<tr>
<td></td>
<td>2=Focus on treatment adherence including some creative methods of improving adherence</td>
</tr>
<tr>
<td></td>
<td>3=Focus on surveillance but no mention of actions to be taken in response to symptoms (e.g., no flexible diuretic management)</td>
</tr>
<tr>
<td></td>
<td>4=Emphasis on surveillance, management, and evaluation of symptoms in addition to treatment adherence</td>
</tr>
<tr>
<td><strong>Medication management</strong></td>
<td>0=No mention of medication regimen</td>
</tr>
<tr>
<td></td>
<td>1=Some mention of medications (e.g., importance of medication compliance) but not an active part of the intervention. No attempt to intervene with provider to get patients on an evidence-based medication regimen</td>
</tr>
<tr>
<td></td>
<td>2=Evidence-based medication regimen advocated but no follow-up with patient or provider to monitor the suggestion</td>
</tr>
<tr>
<td></td>
<td>3=Medication regimen monitored, attempt made to get the patient on evidence-based medications, with follow-up monitoring done with patient or provider</td>
</tr>
<tr>
<td><strong>Social support</strong></td>
<td>0=No mention of a peer support intervention</td>
</tr>
<tr>
<td></td>
<td>1=Peer support mentioned but not integral to intervention</td>
</tr>
<tr>
<td></td>
<td>2=Peer support integral component of intervention</td>
</tr>
<tr>
<td><strong>Surveillance by provider:</strong></td>
<td>0=No use of remote monitoring or telehealth</td>
</tr>
<tr>
<td></td>
<td>1=Remote monitoring is used in conjunction with other interventions that form the main intervention used</td>
</tr>
<tr>
<td></td>
<td>2=Telehealth is essential component of intervention</td>
</tr>
<tr>
<td><strong>Remote monitoring</strong></td>
<td>1=Single generalist provider (e.g., physician, nurse, pharmacist)</td>
</tr>
<tr>
<td></td>
<td>2=Single HF expert provider (e.g., physician, nurse, pharmacist)</td>
</tr>
<tr>
<td></td>
<td>3=Multidisciplinary intervention</td>
</tr>
<tr>
<td><strong>Delivery personnel</strong></td>
<td>1=Mechanized via internet or telephone</td>
</tr>
<tr>
<td></td>
<td>2=Person-to-person by telephone</td>
</tr>
<tr>
<td></td>
<td>3=Face-to-face, individual, or in a group</td>
</tr>
<tr>
<td></td>
<td>4=Combined: Face-to-face at least once alone or in a group with individual telephone calls in between meetings</td>
</tr>
<tr>
<td><strong>Intensity and complexity</strong></td>
<td>1=≤1 mo</td>
</tr>
<tr>
<td></td>
<td>2=≤3 mo</td>
</tr>
<tr>
<td></td>
<td>3=≤6 mo</td>
</tr>
<tr>
<td></td>
<td>4=&gt;6 mo</td>
</tr>
<tr>
<td><strong>Frequency of Follow-up</strong></td>
<td>1=Low: single contact with little or no follow-up</td>
</tr>
<tr>
<td></td>
<td>2=Moderate: &gt;1 but &lt;4 and/or infrequent contact or contacts of short duration</td>
</tr>
<tr>
<td></td>
<td>3=High: multiple contacts of significant duration</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>1=Hospital: Inpatient only</td>
</tr>
<tr>
<td></td>
<td>2=Clinic/outpatient setting</td>
</tr>
<tr>
<td></td>
<td>3=Home-based</td>
</tr>
<tr>
<td></td>
<td>4=Combination of settings</td>
</tr>
</tbody>
</table>
### Appendix 2: List of Covariates for Propensity Match

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source Database</th>
<th>Odds Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Age at time of admission for index event (CIHI)</td>
<td>0.969 (0.964, 0.973)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>CIHI</td>
<td>1.34 (1.18, 1.53)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Residence (Local Health Integration Network)*</td>
<td>Local Health Integration Network (1-14) of residence in CIHI discharge abstracts at time of index event</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lhin_00</td>
<td></td>
<td>48.8 (5.8, 408.7)</td>
<td>0.0003</td>
</tr>
<tr>
<td>lhin_01</td>
<td></td>
<td>3.5 (0.43, 27.5)</td>
<td>0.2375</td>
</tr>
<tr>
<td>lhin_02</td>
<td></td>
<td>10.8 (1.43, 80.5)</td>
<td>0.0208</td>
</tr>
<tr>
<td>lhin_03</td>
<td></td>
<td>59.5 (8.27, 428.4)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_04</td>
<td></td>
<td>45.5 (6.35, 326.0)</td>
<td>0.0001</td>
</tr>
<tr>
<td>lhin_05</td>
<td></td>
<td>31.1 (4.27, 227.0)</td>
<td>0.0007</td>
</tr>
<tr>
<td>lhin_06</td>
<td></td>
<td>153.9 (21.3, 1111.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_07</td>
<td></td>
<td>65.34 (9.1, 1468.2)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_08</td>
<td></td>
<td>63.5 (8.8, 454.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_09</td>
<td></td>
<td>72.4 (10.1, 1517.95)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_10</td>
<td></td>
<td>16.6 (2.27, 122.9)</td>
<td>0.0058</td>
</tr>
<tr>
<td>lhin_11</td>
<td></td>
<td>71.0 (9.9, 507.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_12</td>
<td></td>
<td>57.1 (7.9, 412.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>lhin_13</td>
<td></td>
<td>6.2 (0.82, 47.3)</td>
<td>0.0767</td>
</tr>
<tr>
<td>lhin_14</td>
<td></td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td>Rurality Index for Ontario (RIO)</td>
<td>Statistics Canada Postal Code Conversion file and Census data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td>2.30 (0.21, 24.3)</td>
<td>0.486</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td>3.98 (0.38, 41.6)</td>
<td>0.2489</td>
</tr>
<tr>
<td>Missing</td>
<td></td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td>Neighbourhood Income Equivalent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>0.455 (0.160, 1.290)</td>
<td>0.1387</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.548 (0.193, 1.553)</td>
<td>0.258</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.497 (0.175, 1.411)</td>
<td>0.1893</td>
</tr>
<tr>
<td>Condition</td>
<td>ICD-10 Codes</td>
<td>Odds Ratio (95% CI)</td>
<td>P Value</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>ICD-10 codes I20; I21.I22; I24 :I25; I513</td>
<td>0.593(0.209,1.68)</td>
<td>0.3266</td>
</tr>
<tr>
<td>Old myocardial infarction</td>
<td>ICD-10 code I25</td>
<td>1.139(0.888,1.460)</td>
<td>0.3051</td>
</tr>
<tr>
<td>Diabetes mellitus (Yes/No)</td>
<td>Presence in Ontario Diabetes database 2007 database at any point before index event</td>
<td>1.309(1.0258,1.671)</td>
<td>0.0304</td>
</tr>
<tr>
<td>Hypertension (Yes/No)</td>
<td>Presence in Hypertension 2007 database at any point before index event</td>
<td>1.057(0.900,1.24)</td>
<td>0.4982</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>ICD-10 codes I60 – I68; I69; G45; G46, H34.</td>
<td>0.827(0.615,1.11)</td>
<td>0.211</td>
</tr>
<tr>
<td>Chronic cerebrovascular disease</td>
<td>ICD-10 code I69</td>
<td>0.810(0.481,1.362)</td>
<td>0.4275</td>
</tr>
<tr>
<td>Chronic renal insufficiency (Yes/No)</td>
<td>(1) ICD-10 codes I12.0; I13.1; N03.2-N03.7; N05.2-N05.7; N18; N19; N25.0; Z49.0-Z49.2; Z94.0; Z99.2.</td>
<td>1.046(0.853,1.283)</td>
<td>0.662</td>
</tr>
<tr>
<td>Chronic pulmonary disease (Yes/No)</td>
<td>ICD-10 codes I27.8; I27.9; J40-J47; J60-J67; J68.4; J70.1; J70.3.</td>
<td>0.804(0.687,0.942)</td>
<td>0.0069</td>
</tr>
<tr>
<td>Dementia (Yes/No)</td>
<td>ICD-10 codes F00 - F03; F05.1; G30; G31.1</td>
<td>0.575(0.414,0.800)</td>
<td>0.001</td>
</tr>
<tr>
<td>Malignancy (Yes/No) – non-melanoma skin tumours excluded</td>
<td>ICD-10 codes: C00-26; C30-C34; C37-C41; C43; C45-C58; C60-C85; C88; C90-C97.</td>
<td>0.904(0.6772,1.208)</td>
<td>0.4966</td>
</tr>
<tr>
<td>Charlson Comorbidity Index</td>
<td>Entire score. ICD-10 codes in CIHI discharge abstracts Yes/No. ICD-10 codes in CIHI discharge abstracts.</td>
<td>1.434(0.998,2.061)</td>
<td>0.0513</td>
</tr>
<tr>
<td>Adjusted Clinical Group (ACG)</td>
<td>ICD -10 codes from CIHI</td>
<td>1.268(0.936,1.718)</td>
<td>0.1248</td>
</tr>
<tr>
<td>&lt;=3</td>
<td></td>
<td>1.257(0.984,1.606)</td>
<td>0.0669</td>
</tr>
<tr>
<td>&gt;=5</td>
<td></td>
<td>0.938(0.757,1.163)</td>
<td>0.563</td>
</tr>
</tbody>
</table>
CIHI: Canadian Institute for Health Information;

*The LHIN (local health integration networks) represent 14 regions across the province of Ontario. In 2006, the Ontario Ministry of Health and Long-Term Care transferred the responsibility for planning, integrating and funding of health services within the province to these 14 LHINs.
Appendix 3: Co-variates for Risk Adjustment based on Krumholz Model

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>ICD-10 Codes</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>the Krumholz model</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intercept</td>
<td></td>
<td>We use age as continuous variable</td>
</tr>
<tr>
<td></td>
<td>Age, years over 65</td>
<td>I41 I42 I43 I50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td>Not included in our model since it is not significant</td>
</tr>
<tr>
<td></td>
<td>History of CABG</td>
<td>I21 I22 I23 I512</td>
<td>Included in our model</td>
</tr>
<tr>
<td></td>
<td>History of PCI</td>
<td>I20 I24 I513</td>
<td>Included in our model</td>
</tr>
<tr>
<td>1</td>
<td>History of heart failure</td>
<td>I41 I42 I43 I50</td>
<td>Included in our model</td>
</tr>
<tr>
<td>2</td>
<td>History of MI</td>
<td>I21 I22 I23 I512</td>
<td>Included in our model</td>
</tr>
<tr>
<td>3</td>
<td>Unstable angina</td>
<td>I200 I24 I513</td>
<td>Included in our model</td>
</tr>
<tr>
<td>4</td>
<td>Chronic atherosclerosis</td>
<td>I201 I2080 I2088 I209 I25</td>
<td>Included in our model</td>
</tr>
<tr>
<td>5</td>
<td>Cardiopulmonary-respiratory failure and shock</td>
<td>I46 J80 J81 J95 R090 R57 R96</td>
<td>Included in our model</td>
</tr>
<tr>
<td>6</td>
<td>Valvular heart disease</td>
<td>I00-I02 I05-I09 I34-I39 Q22 Q23</td>
<td>Included in our model</td>
</tr>
<tr>
<td>7</td>
<td>Hypertension</td>
<td>I10 I12 I13 I15</td>
<td>Included in our model</td>
</tr>
<tr>
<td>8</td>
<td>Stroke</td>
<td>G46 I60 I61 I62 I63 I64</td>
<td>Included in our model</td>
</tr>
<tr>
<td>9</td>
<td>Renal failure</td>
<td>N17 N18 N19</td>
<td>Included in our model</td>
</tr>
<tr>
<td>10</td>
<td>COPD</td>
<td>J41 J42 J43 J44 J98</td>
<td>Included in our model</td>
</tr>
<tr>
<td>11</td>
<td>Pneumonia</td>
<td>A22 A420 A430 A481 B052 J10-J18 J69 J85 J86 R091</td>
<td>Included in our model</td>
</tr>
<tr>
<td>12</td>
<td>Diabetes</td>
<td>E10 E11 E13 E14 G632 H360</td>
<td>Included in our model</td>
</tr>
<tr>
<td>13</td>
<td>Protein-calorie malnutrition</td>
<td>E40-E46 E64 R64</td>
<td>Included in our model</td>
</tr>
<tr>
<td>14</td>
<td>Dementia</td>
<td>A81 E75 F00-F07 F09 F84 G30 G31 G328 G91 G93 G94 G98 G998 R54</td>
<td>Included in our model</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>ICD-10 Codes</td>
<td>Included in our model</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------</td>
<td>--------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>15</td>
<td>Hemiplegia, paraplegia, paralysis, functional disability</td>
<td>G04 G11 G13 G320 G54 G55 G80 G81 G82 G83 G90 G95 G992 Q00 Q01 Q02 Q03 Q04 Q05 Q06 Q07 S14 S24 S34 T08 T913 T926 T936 Z44</td>
<td>Included in our model</td>
</tr>
<tr>
<td>16</td>
<td>Peripheral vascular disease</td>
<td>A480 I70-I74 I77 I78-I80 I82 K55 M30 M31 R02</td>
<td>Included in our model</td>
</tr>
<tr>
<td>17</td>
<td>Metastatic cancer</td>
<td>C15-C17 C22-C25 C33 C34 C38 C45 C46 C48 C77-C80 C88 C90-C95 C97</td>
<td>Included in our model</td>
</tr>
<tr>
<td>18</td>
<td>Trauma in last year</td>
<td>M48 M49 M80 M84 M90 S00-S03 S05-S13 S15-S23 S25-S33 S35-S43 S45-S53 S55-S63 S65-S73 S75-S83 S85-S93 S95-S99 T00-T07 T09-T14 T87000 T87001 T87008 T87009 T87010 T87011 T87018 T87019 T87020 T87021 T87028 T87029 T87090 T87091 T87098 T87099 T87100 T87101 T87108 T87109 T87110 T87111 T87118 T87119 T87120 T87121 T87128 T87129 T87190 T87191 T87198 T87199 T87200 T87201 T87208 T87209 T90 T910-T912 T914 T915 T918-T925 T928-T935 T938 T939 T94-T98 V01-V06 V09-V99 W00-W45 W49-W60 W64-W70 W73-W81 W83-W94 W99 X00-X06 X08-X39 X50-X54 X57-X59 X7409 X85-X99 Y00-Y36 Y85 Y86 Y871 Y872 Y89-Y91 Y95-Y98</td>
<td>Included in our model</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Major psychiatric disorders</td>
<td>F20-F25 F28-F34 F38 F39 R41 X60-X73 X7400 X7401 X7408 X75-X84 Y870</td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>----------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Chronic liver disease</td>
<td>I85 I982 K70 K72 K73 K74 K76 K77</td>
</tr>
</tbody>
</table>
Appendix 4: Disease management interventions in heart failure clinics* (n = 21)

<table>
<thead>
<tr>
<th>Intervention category</th>
<th>Clinic intensity types</th>
<th>High (n = 8)</th>
<th>Medium (n = 8)</th>
<th>Low (n = 5)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recipient</td>
<td></td>
<td>3.8 (0.5)</td>
<td>3.4 (0.7)</td>
<td>3.2 (0.4)</td>
<td>0.239</td>
</tr>
<tr>
<td>Education and counselling aimed at supporting self-care</td>
<td></td>
<td>4.0(0)</td>
<td>3.3 (1.0)</td>
<td>2.8 (1.1)</td>
<td>0.050</td>
</tr>
<tr>
<td>Medication management</td>
<td></td>
<td>3.0 (0)</td>
<td>3.0 (0)</td>
<td>2.4 (0.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>Social support</td>
<td></td>
<td>0.6 (0.7)</td>
<td>0.25 (0.5)</td>
<td>0.4 (0.5)</td>
<td>0.474</td>
</tr>
<tr>
<td>Peer support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveillance by provider:</td>
<td></td>
<td>0.9 (0.8)</td>
<td>1.1 (0.8)</td>
<td>0.2 (0.4)</td>
<td>0.130</td>
</tr>
<tr>
<td>Remote monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery personnel</td>
<td></td>
<td>3.5 (0.5)</td>
<td>2.5 (0.8)</td>
<td>2.0 (1.2)</td>
<td>0.011</td>
</tr>
<tr>
<td>Method of communication</td>
<td></td>
<td>4.0 (0)</td>
<td>3.8 (0.5)</td>
<td>3.4 (0.5)</td>
<td>0.045</td>
</tr>
<tr>
<td>Duration</td>
<td></td>
<td>4.0 (0)</td>
<td>4.0 (0)</td>
<td>4.0 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Frequency of Follow-up</td>
<td></td>
<td>3.0 (0.7)</td>
<td>2.6 (0.5)</td>
<td>2 (0.7)</td>
<td>0.518</td>
</tr>
<tr>
<td>Environment</td>
<td></td>
<td>2.0 (0)</td>
<td>2.0 (0)</td>
<td>2.0 (0)</td>
<td>-</td>
</tr>
</tbody>
</table>
## Appendix 5: Relationship between Clinic Intensity Strata and Outcomes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HR (95% CI)</th>
<th>P-value</th>
<th>HR (95% CI)</th>
<th>P-value</th>
<th>HR (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEATH</td>
<td></td>
<td>HF ADMISSION</td>
<td></td>
<td>ALL ADMISSION</td>
<td></td>
</tr>
<tr>
<td>Low Intensity</td>
<td>Referent</td>
<td></td>
<td>Referent</td>
<td></td>
<td>Referent</td>
<td></td>
</tr>
<tr>
<td>Medium Intensity</td>
<td>1.09(0.908,1.321)</td>
<td>0.36</td>
<td>1.14(0.86,1.52)</td>
<td>0.36</td>
<td>1.03(0.68,1.25)</td>
<td>0.75</td>
</tr>
<tr>
<td>High Intensity</td>
<td>1.03(0.88,1.21)</td>
<td>0.69</td>
<td>0.93(0.74,1.20)</td>
<td>0.62</td>
<td>0.83(0.68,1.01)</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Appendix 6: EFFECT II HF cohort: Standardized Differences of baseline covariates in original and matched sample

<table>
<thead>
<tr>
<th>LVEF: left ventricular ejection fraction</th>
<th>HF Clinic</th>
<th>Non-HF clinic</th>
<th>Standardized difference (matched sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=621</td>
<td>N=621</td>
<td></td>
</tr>
<tr>
<td>Age (years, Mean ± SD)</td>
<td>72.88 ± 13.03</td>
<td>72.65 ± 12.45</td>
<td>0.02</td>
</tr>
<tr>
<td>Male , N(%)</td>
<td>337 (54.3%)</td>
<td>352 (56.7%)</td>
<td>0.05</td>
</tr>
<tr>
<td>LVEF &lt;=45%</td>
<td>332 (53.5%)</td>
<td>251 (40.4%)</td>
<td>0.13</td>
</tr>
<tr>
<td>&gt;45%</td>
<td>104 (16.7%)</td>
<td>140 (22.5%)</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Appendix 7: Sensitivity Analysis for Survivorship Bias

Table A7.1: Landmark Analysis

<table>
<thead>
<tr>
<th>Death over 4 years of follow-up</th>
<th>n</th>
<th>HF clinic</th>
<th>non-HF clinic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANDMARK – 1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(all of HF clinic patients seen)</td>
<td>995</td>
<td>37.9%</td>
<td>39.1%</td>
<td>0.64</td>
</tr>
<tr>
<td>LANDMARK – 30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(50% of HF clinic patients seen)</td>
<td>1,267</td>
<td>51.2%</td>
<td>53.9%</td>
<td>0.48</td>
</tr>
</tbody>
</table>
Figure A7.1: Sensitivity Analyses with random start dates for non-HF clinic patients

**KM curves in PS-Matched sample: Time to death**

- Survival probability over time to death (days).
- HF Clinic and Non-HF clinic curves.
- P-value: 0.26

**KM curves in PS-matched sample: Time to all-cause readmission**

- Survival probability over time to all-cause readmission (days).
- HF Clinic and Non-HF clinic curves.
- P-value: 0.07

**KM curves in PS-matched sample: Time to HF readmission**

- Survival probability over time to HF readmission (days).
- HF Clinic and Non-HF clinic curves.
- P-value: <0.001