

Case Management in a Heterogeneous Congestive Heart Failure Population

A Randomized Controlled Trial

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Background: Both randomized and nonrandomized controlled studies have linked congestive heart failure (CHF) case management (CM) to decreased readmissions and improved outcomes in mostly homogeneous settings. The objective of this randomized controlled trial was to test the effect of CHF CM on the 90-day readmission rate in a more heterogeneous setting.

Methods: A total of 287 patients admitted to the hospital with the primary or secondary diagnosis of CHF, left ventricular dysfunction of less than 40%, or radiologic evidence of pulmonary edema for which they underwent diuresis were randomized. The intervention consisted of 4 major components: early discharge planning, patient and family CHF education, 12 weeks of telephone follow-up, and promotion of optimal CHF medications.

Results: The 90-day readmission rates were equal for the CM and usual care groups (37%). Total inpatient and

outpatient median costs and readmission median cost were reduced 14% and 26%, respectively, for the intervention group. Patients in the CM group were more likely to be taking CHF medication at target doses, but dosages did not increase significantly throughout 12 weeks. Although both groups took their medications as prescribed equally well, the rest of the adherence to treatment plan was significantly better in the CM group. Subgroup analysis of patients who lived locally and saw a cardiologist showed a significant decrease in CHF readmissions for the intervention group ($P=.03$).

Conclusions: These results suggest several limitations to the generalizability of the CHF CM-improved outcome link in a heterogeneous setting. One explanation is that the lack of coordinated system supports and varied accessibility to care in an extended, nonnetworked physician setting limits the effectiveness of the CM.

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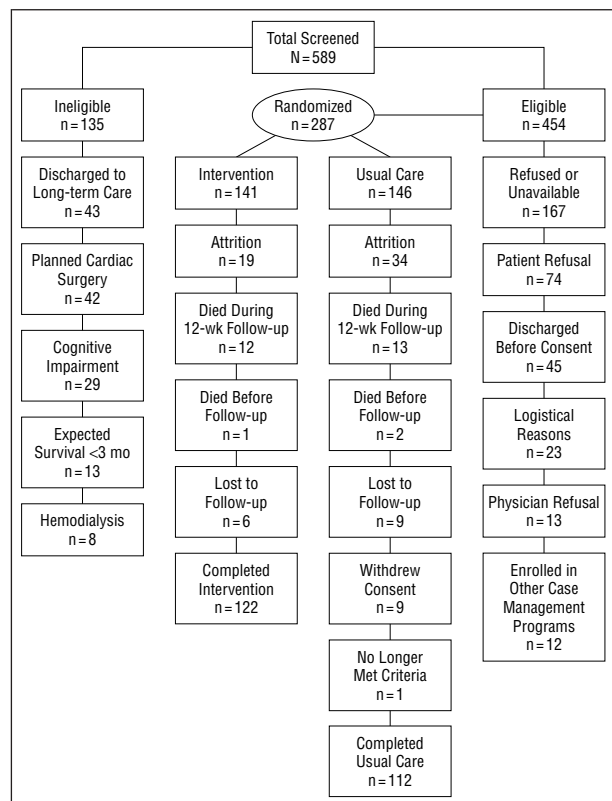
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IN 1998, CONGESTIVE heart failure (CHF) was responsible for approximately 978 000 hospital discharges in the United States. This number has increased 159% since 1979. Close to 5 million people in the United States have CHF, and there are approximately 550 000 new diagnoses each year.¹ As the population ages, CHF will only become more prevalent and costly.²⁻⁴ Because of its high medical resource consumption, expenditures related to the care of CHF patients are expected to climb dramatically.⁵ Congestive heart failure is the leading cause of hospitalization among elderly people in Vermont (15.8 admissions per 1000 population).⁶

Both randomized and nonrandomized controlled studies have linked CHF case management strategies to decreased readmissions,⁷⁻¹⁰ cost savings,¹¹⁻¹³ and improved functional health status.¹⁰ Thus, up to 50% of readmissions may be preventable⁸ through improved patient educa-

tion,^{7,10,12,14} comprehensive discharge planning,¹⁵⁻¹⁷ and enhanced follow-up.¹⁸ The ability to generalize across studies is limited, however, because testing occurred in highly preselected patient populations.

This study is characterized by a heterogeneous CHF population, one that includes patients of all ages, of all insurance types, with either normal left ventricular function or dysfunction, in all New York Heart Association (NYHA) classes, having any comorbidity, and with either primary or secondary heart failure. All were hospitalized at Fletcher Allen Health Care, Burlington, Vt, a 550-bed academic medical center, which serves the largely rural geographic areas of Vermont and Upstate New York. Like most patients who receive care at tertiary care centers, patients in this study received postdischarge care locally from their own cardiologists, internists, or family practitioners. Many of these practitioners function in a nonnetworked, geographically



Randomization of patients in the study.

dispersed care setting characterized by considerable variation in follow-up care.

The objective of this randomized controlled trial was to test the effect of hospital-based nurse case management on readmission rate in this population. The hypothesis was that the case-managed CHF patients would exhibit a 50% lower 90-day readmission rate than the usual care group patients and maintain equivalent or better adherence to plan of care; patient satisfaction; dosage of angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), or β -blockers (BBs); and total cost.

METHODS

STUDY COHORT

From July 5, 1999, through April 30, 2001, 589 (92%) of 640 patients admitted to the hospital with CHF were screened for study participation. Clinical signs and symptoms for CHF^{19,22} and either moderate-to-severe left ventricular dysfunction or radiographic evidence of pulmonary congestion and symptomatic improvement following diuresis were required for study participation. Patients with confirmed CHF also had to be at risk for early readmission as defined by the presence of 1 or more of the following criteria: history of CHF, documented knowledge deficits of treatment plan or disease process, potential or ongoing lack of adherence to treatment plan, previous CHF hospital admission, living alone, and 4 or more hospitalizations in the past 5 years.^{8,23,24} Exclusion criteria likewise were chosen from previous studies^{7,9,11} and investigators' clinical experience and included discharge to a long-term care facility, planned cardiac surgery, cognitive impairment, anticipated survival of fewer than 3 months, and long-term hemodialysis.

Of the 589 patients screened, 135 patients met 1 of the exclusion criteria and 167 refused to participate or were unavailable. A total of 287 patients admitted to the hospital with primary CHF or CHF secondary to coexisting factors, such as myocardial infarction, chronic obstructive pulmonary disease, arrhythmias, or pneumonia, fulfilled study criteria and were enrolled. After simple randomization of the first 42 patients resulted in large amounts of patients being assigned to one group or the other, patients were randomized in blocks of 8 to ensure an even group allocation across time. Most patients were enrolled by the clinical research coordinator (CRC) (J.S.); if unavailable, the principal investigator (A.S.L.) substituted. On randomization, 141 patients were assigned to the intervention group and 146 to the usual care group. Early attrition accounted for 53 patients because of death, withdrawal of consent, failure to continue to meet study criteria, or loss to follow-up. A total of 122 patients in the intervention group and 112 patients in the usual care group completed the 90-day study period (Figure). The institutional review board of the University of Vermont approved the study and all patients gave written informed consent.

STUDY INTERVENTION

The intervention was performed by one CHF case manager (CM) (A.S.L.), who holds a master's degree and has 18 years of experience in critical care and cardiology. Four major components were (1) early discharge planning and coordination of care,²⁵ (2) individualized and comprehensive patient and family education,^{19,26,27} (3) 12 weeks of enhanced telephone follow-up and surveillance,¹¹ and (4) promotion of optimal CHF medications and medication doses (ACEIs or ARBs and BBs) based on consensus guidelines.¹⁹⁻²²

While the patient was in the hospital and for the next 12 weeks, the CM assisted in the coordination of care by facilitating the discharge plan and obtaining needed consultations from social services, dietary services, and physical therapy/occupational therapy (PT/OT). When indicated, arrangements were made for additional services or support once the patient had returned home. The CM also facilitated communication in the hospital among the patient and family, attending physician, cardiology team, and other medical care practitioners through participating in daily rounds, documenting patient needs in the medical record, submitting progress reports to the primary care physician (PCP), involving the patient and family in developing the plan of care, collaborating with the home health agencies, and providing informational and emotional support to the patient and family. After the patient was discharged from the hospital, a letter was sent to the PCP and/or the responsible physician (cardiologist) that informed them of their patient's participation in the study and outlined the case management program. At completion of the 12-week study, the PCP received a letter that summarized the patient's condition and progress in the program.

Each day in the hospital and with every telephone contact, the CM conducted and then reinforced the education plan with the patient and family. The education categories, consistent with evidence-based guidelines,^{19,26} included the following: disease process of CHF, diet and fluid recommendations, instruction about each medication and overall dosing plan, self-monitoring of signs and symptoms and their management, activity recommendations, cardiac risk factor modification, prognosis, and counseling.

The patient received educational materials, including a 15-page CHF booklet called *Heartworks* developed by personnel in the institution, weight logs, self-care activities summary sheets, computerized medication lists, and a guide for measuring sodium intake. Home scales and pillboxes were made available as needed. The self-care topics emphasized were adherence to

medication regimen, diet and fluid recommendations, daily monitoring of weight and edema, and CHF symptoms and management if symptoms occurred.

Patient and/or family members received telephone calls at 1 to 3 days after discharge and at weeks 1, 2, 3, 4, 6, 8, 10, and 12. Time spent with each patient and family per telephone call ranged from 5 to 45 minutes. The telephone calls surveyed CHF symptoms, laboratory values, medications, self-care activities, adherence to treatment plan and cardiac risk factor modification, next PCP appointment time, and resources and opportunity for patients and families to ask questions. Patients were instructed to contact their physician anytime a change in symptoms occurred. If symptoms or signs of CHF were detected during a routine telephone call, appropriate triage occurred and additional telephone calls to the patient were prompted. The CM was also available as a resource Monday through Friday during daytime hours. The caseload for the CM was between 65 and 89 cases at any one time and included study and nonstudy patients.

During the patient's hospitalization, monitoring of CHF medications and medication doses occurred and appropriate recommendations were made. At week 6, if the patient was not taking an ACEI or ARB and a BB was appropriate or if he or she was not at target doses, a recommendation letter was sent to the responsible physician as a courtesy reminder. In addition, patients and families were informed of appropriate medication recommendations and encouraged to discuss these with their physicians.

USUAL CARE

The patients randomized to the usual care group received standard care, typical of a tertiary care hospital, and all conventional treatments requested by the attending physician. Inpatient treatments included social service evaluation (25% for usual care group), dietary consultation (15% usual care), PT/OT (17% usual care), medication and CHF education by staff nurses, and any other hospital services. Postdischarge care was conducted by the patient's own local physician. The home care service figures (44% usual care group) are similar to those reported in a previous study.⁷ At no time was any standard care denied, although more intense and supplemental education and follow-up care were provided to the intervention group.

DATA COLLECTION

Data were collected at enrollment by the CM and the CRC through patient interview, medical record review, and consulting with attending physicians. These data included demographics, risk factors for cardiovascular disease, CHF readmission risk, comorbidity, NYHA classification, and relevant elements of the patient's medical history and hospital course. The ACEI, ARB, and BB doses were collected at discharge and at 12 weeks after discharge. Patients were followed up for 12 weeks after discharge, during which time all inpatient (including readmissions) and outpatient health services used were recorded and verified through a combination of patient, practitioner, and administrative report.

Adherence to treatment plan was measured by patient self-report at 4 and 12 weeks. The instrument consisted of 5 items on which the patient was asked to rate adherence on a scale from 1 (never) to 5 (always). Question topics included weighing, edema assessment, fluid and sodium recommendations, and medications. This instrument, although not validated, was developed and used in a previous study.²⁸

Patient satisfaction was measured at 4 weeks using a 16-item participant survey consisting of 4 item subscales: hospital care, hospital discharge, care instructions, and recovering at home. The survey was adapted from the literature²⁹ and the hospital's patient satisfaction survey with particular questions

in mind to evaluate the intervention. For each item, patients rated practitioner performance on a scale from 1 (worst) to 5 (best). Qualitative comments were also collected. The interview was conducted over the telephone by the CRC after the patient received a mailed copy of the survey to preview.

All patients maintained a log of outpatient and inpatient health services used during the 12-week study period. These data were collected at 4, 8, and 12 weeks by the CM (intervention group) or CRC (usual care group). Outpatient services collected were PCP visits, cardiologist visits, other specialty care practitioner visits, emergency department (ED) visits, and all services provided by home health agencies (PT/OT, home-maker, registered nurse, nurse aide, and social worker). All home care visits were verified with the appropriate agencies, whereas other outpatient services were verified with respective practitioners only when patients were poor historians.

Home health agencies provided charge data for all home care services. All other outpatient cost data were derived using the hospital's standard charges as of December 11, 2000. Primary care (\$64) and cardiologist (\$97) visit charges were based on 15-minute office rates, whereas the cost of an ED visit (\$662) was based on the average charge during the study period. Inpatient services and charges (readmissions and the initial index hospitalization) were all verified with the respective hospitals.

STUDY END POINTS

All-cause readmission during the 90-day postdischarge period was the primary end point. Secondary end points included adherence to the treatment plan; patient satisfaction; ACEI, ARB, and BB dosages; and the overall cost of medical care. Other clinical end points included cause for readmission, length of stay, number of CHF readmissions, cumulative number of hospital days, and number of days to first readmission.

STATISTICAL ANALYSIS

The intervention and usual care groups were compared using the Fisher exact test for categorical variables and 2-sample *t* tests for continuous variables. The Wilcoxon rank sum test was also used for continuous variables that were not approximately normally distributed. Since these results did not differ from those of the 2-sample *t* tests, only the *t* test findings are presented.

For analysis of hospital readmission, baseline differences between the groups were adjusted for unconditional logistic regression. Both logistic regression and stratified analyses were used to determine if the intervention effect differed for patients with different illness severity. Readmission rates were calculated as the percentage of patients admitted at least once to any hospital during the study period of 90 days.

To include all randomized patients in the analysis, including those with incomplete follow-up, hospital readmission was also examined using Kaplan-Meier survival analysis. Patients who withdrew, died, or were otherwise lost before 90 days of follow-up were censored on the day of early attrition. The groups were compared on time to readmission using the log-rank test and using proportional hazards regression to adjust for baseline differences.

RESULTS

PATIENT CHARACTERISTICS

Study patients as a whole were elderly, with a mean age of 70.7 years (SD, 11.8 years) and a relatively even sex distribution. The most common underlying cause of heart failure was ischemic heart disease (71%). Approxi-

Table 1. Demographic Comorbid Severity Characteristics

Characteristic	No. (%)		P Value
	Intervention (n = 141)	Control (n = 146)	
Demographics			
Female sex	59 (42)	72 (50)	.19
Age, mean (SD), y	70.6 (11.4)	70.8 (12.2)	.86
Married	72 (51)	79 (54)	.66
Education <high school graduate	54 (39)	59 (41)	.40
Annual income, \$			
<10 000	34 (25)	30 (23)	.21
10 000-15 000	24 (17)	36 (28)	
15 000-30 000	40 (29)	34 (27)	
30 000-50 000	29 (21)	17 (13)	
>50 000	11 (8)	11 (9)	
Comorbidities			
Hypertension	100 (71)	111 (77)	.29
Diabetes mellitus	62 (44)	61 (42)	.81
COPD	36 (26)	28 (19)	.26
Peripheral vascular disease	27 (19)	15 (10)	.05
Smoker	27 (19)	26 (18)	.88
Hyperlipidemia	77 (55)	88 (61)	.34
Obesity	63 (45)	74 (51)	.29
Prior myocardial infarction	62 (44)	58 (40)	.55
Myocardial infarction this admission	33 (23)	33 (23)	>.99
Ischemic origin for heart failure	97 (68)	106 (74)	.36
CHF as primary diagnosis	78 (55)	69 (48)	.24
Severity			
Left ventricular dysfunction			
Normal to mild	27 (20)	29 (21)	.18
Moderate	15 (11)	26 (19)	
Moderate-severe	20 (15)	22 (16)	
Severe	73 (54)	58 (43)	
NYHA functional class, mean (SD)	2.5 (0.6)	2.2 (0.8)	<.001
Class I	10 (7)	35 (26)	
Class II	76 (55)	47 (36)	
Class III	50 (36)	46 (35)	
Class IV	3 (2)	4 (3)	
Index length of stay, mean, d	6.0 (4.5)	6.9 (6.0)	.14
Support at home (yes)	127 (90)	140 (97)	.03
Visiting nurse after discharge	70 (50)	64 (44)	.41
Risk factors for readmission			
Prior CHF	76 (54)	68 (47)	.24
Prior CHF admission	43 (31)	26 (18)	.02
Lives alone	46 (33)	38 (26)	.25
≥4 Hospitalizations in past 5 y	23 (16)	15 (10)	.16
Knowledge deficits	122 (87)	113 (78)	.07
Lack of adherence to treatment plan	41 (29)	27 (19)	.05
Sum of readmission risk factors, mean (SD)	2.5 (1.3)	2.0 (0.9)	<.001
Deceased	13 (9)	15 (10)	.84

Abbreviations: CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association.

mately half the population had severe left ventricular dysfunction, and 20% had normal-to-mild dysfunction or what could be classified as diastolic dysfunction. Most study patients (82%) left the hospital taking an ACEI or an ARB, and 63% were taking BBs. Congestive heart failure was the primary diagnosis for 51% of study patients. Other primary diagnoses were atrial fibrillation (8%), myo-

Table 2. Readmissions and Length of Stay*

Variable	Intervention (n = 131)	Control (n = 125)	P Value†
Length of stay for initial admission, d			
Mean (SD)	5.5 (3.5)	6.4 (5.2)	.10
Median (interquartile range)	5 (3-7)	5 (3-7)	.35
Readmission, No. (%)‡			
90-d readmission	49 (37)	46 (37)	>.99
CHF readmission§	18 (14)	21 (17)	.49
Cardiac readmission	15 (11)	10 (8)	.40
Other readmission	24 (18)	23 (18)	>.99
Readmission days in hospital only for patients with ≥1 readmission			
Mean (SD)	6.9 (6.5)	9.5 (9.8)	.15
Median (interquartile range)	5 (2-8)	7 (2-10)	.37

Abbreviation: CHF, congestive heart failure.

*Excluding patients whose participation was terminated early and were not known to have been readmitted.

†Two-sample *t* test for means. Wilcoxon rank sum test for medians, and the Fisher exact test for readmissions.

‡Total patients with ≥1 readmission is less than the total of CHF, cardiac, and other because some patients had different reasons for different readmissions.

§Using logistic regression to control for variables that differed between groups did not change these results.

cardial infarction (19%), unstable angina (2%), and ventricular tachycardia (2%). The intervention and usual care groups were comparable with respect to most patient characteristics. Patients in the intervention group were more likely to have peripheral vascular disease ($P = .05$). They also had higher overall severity signified by NYHA functional class after hospital discharge ($P < .001$), reported less support at home ($P = .03$), and had more risk factors for readmission ($P < .001$) (**Table 1**). These differences between the groups were due to chance.

READMISSIONS

There was no difference in total readmissions between the groups, with both at 37%. Similar results were found using life table analysis. Reasons for readmission in the intervention and usual care groups were similar. Overall, most readmissions for both groups were for CHF. Re-admission for unstable angina was the reason for most of the cardiac readmissions. Readmissions for CHF were fewer in the intervention group (14% vs 17%) than in the usual care group, although the difference was not significant ($P = .49$). In the subgroup of patients who lived locally and saw a local cardiologist, the intervention group had significantly fewer CHF readmissions than the usual care group (1 [2%] of 50 for the intervention group vs 7 [14%] of 49 for the usual care group, $P = .03$). Using logistic regression to control for patient severity, there was still no difference in readmission rates between the groups ($P = .84$). Among readmissions, those in the intervention group required fewer days of hospitalization than those in the usual care group (6.9 vs 9.5, $P = .15$). The number of patients readmitted more than once did not differ for the groups (7% of the intervention group and 8% of the usual care group, $P = .83$). The mean number of readmissions did not differ for the groups ($P = .61$). Predictors of readmission were increasing age ($P < .01$), NYHA

Table 3. Adherence to Plan*

Variable	4-Week Scores			12-Week Scores		
	Intervention	Control	P Value	Intervention	Control	P Value
Weigh self daily	4.7	3.2	<.001	4.6	3.1	<.001
Check ankles and feet for swelling	4.9	4.5	.002	4.8	4.6	.02
Follow fluid recommendation	5.0	4.6	.006	5.0	4.6	.003
Follow low-salt diet	4.9	4.6	<.001	4.8	4.4	<.001
Take medications	5.0	4.9	.15	5.0	4.9	.04

*Scores were as follows: 1, never; 2, rarely; 3, sometimes; 4, usually; and 5, always.

class at discharge ($P<.01$), chronic renal failure ($P=.01$), diabetes ($P=.04$), and chronic obstructive pulmonary disease ($P=.04$). There was no difference in readmissions between the groups when stratifying for NYHA class or left ventricular function. The intervention group also had significantly fewer CHF readmissions than the usual care group for patients admitted initially with weight gain ($n=19$, $P=.03$) or chronic renal failure ($n=9$, $P=.05$) (**Table 2**).

ADHERENCE TO TREATMENT PLAN

The intervention group adhered to the treatment plan better than the usual care group with regard to daily weights, checks for edema, and low-salt diet and fluid recommendations ($P<.01$). Each group took prescribed medications equally well (**Table 3**).

PATIENT SATISFACTION

The satisfaction survey was completed for 91% of the intervention group and 84% of the usual care group. Patients in the intervention group were significantly more satisfied with their care in 13 of 16 items than the usual care group ($P<.01$). All items that measured care instructions and recovering at home were significantly better in the intervention group ($P<.01$) (**Table 4**).

MEDICATIONS

More intervention than usual care group patients were discharged from the hospital taking ACEIs or ARBs ($P=.08$) and BBs ($P=.17$). The number of patients taking target doses of ACEIs or ARBs at discharge and 12 weeks was likewise greater in the intervention group than the usual care group ($P=.08$) (**Table 5**).

COST ANALYSIS

Cost of outpatient services was computed for patients who completed the 12-week study period (132 intervention, 119 usual care). The intervention did not increase costs, and no significant differences were found in outpatient and inpatient resource utilization between the groups (**Table 6**). There was no difference in the use of inpatient services at index hospitalization between the groups (social worker intervention mean, 0.4 vs 0.6 visits; $P=.31$; PT/OT intervention mean, 0.5 vs 0.7 visits; $P=.40$; dietitian intervention mean, 0.2 vs 0.3 visits; $P=.46$). Home

Table 4. Satisfaction Survey*

Variable	Intervention (n = 120)	Control (n = 100)	P Value
Mean hospital care	4.2	4.0	.003
Mean hospital discharge	4.3	4.0	<.001
Mean care instructions	4.0	3.4	<.001
Mean recovering at home	4.4	3.9	<.001
Mean of total score	4.2	3.8	<.001

*Scores were as follows: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; and 5, strongly agree.

Table 5. Medication Use and Target Dose Advancement*

Variable	Intervention	Control	P Value†
No. of patients at discharge	141	145	...
Taking ACEIs or ARBs at discharge	121 (86)	115 (79)	.16
Taking BBs at discharge	91 (65)	89 (61)	.63
Target dose‡			
≥Target dose of ACEI or ARB at discharge	74 (64)	56 (51)	.08
≥Target dose of BB at discharge	28 (33)	18 (23)	.17
No. of patients at 12 weeks	128	113	...
Taking ACEIs or ARBs at 12 weeks	108 (84)	90 (80)	.40
Taking BBs at 12 weeks	89 (70)	70 (62)	.22
Target dose‡			
≥Target dose of ACEI or ARB at 12 weeks	64 (63)	42 (49)	.08
≥Target dose of BB at 12 weeks	27 (32)	18 (29)	.72

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BB, β -blocker; CHF, congestive heart failure.

*Data are presented as number (percentage) of patients who responded yes.

†Fisher exact test.

‡Patients not taking approved CHF medication classified as missing for target dose.

care services were used by 44% of the usual care group and 50% of the intervention group. The outpatient mean cost for the intervention group was \$1552 for 12 weeks, with an average of 18.8 appointments or visits, whereas the mean usual care group cost was \$1307, with an average of 15.9 visits ($P=.28$). The costs for both groups do not include other specialist charges because of the great variability of cost. The intervention and usual care groups had similar numbers of ED visits, 0.3 vs 0.2 per patient, respectively. Because ED costs can be variable, analysis

Table 6. Total 90-Day Cost of Care*

Variable	Intervention	Control	P Value†
Total No. of patients (excluding those lost to follow-up and withdrawn)	135	127	
Initial admission costs, \$			
Mean	16 119	19 081	.18
Median	9691	11 775	.09
Total readmission costs, \$			
Mean	5253	5163	.96
Median	0	0	.68
Total inpatient costs, \$			
Mean	21 373	24 245	.31
Median	12 157	17 609	.10
Total outpatient costs, \$			
Mean	1552	1307	.28
Median	984	714	.37
Total costs, \$			
Mean	23 054	25 536	.39
Median	15 979	18 662	.14
No. of patients readmitted at least once	46	40	
Total readmission costs, \$			
Mean	15 417	16 395	.82
Median	7691	10 377	.94

*Similar results were found if patients who died were excluded. Similar results were found if lost and withdrawn patients with cost information were included. Similar results were found if costs were log transformed. Similar results were found using analysis of variance to control for New York Heart Association class at discharge and readmission risk factor score.

†Two-sample *t* test for means; Wilcoxon rank sum test for medians.

was rerun using the subset of patients for whom actual ED costs were readily available. This resulted in only minor differences in mean outpatient and total costs and did not change the reported trends or conclusions. Total inpatient and outpatient median costs were slightly less for the intervention group (\$15 979 vs \$18 662, $P=.14$). Although not statistically significant, this is a 14.4% reduction in median costs. In addition, the total readmission costs demonstrated a 25.8% median cost reduction. The intervention group was not as likely to see a cardiologist compared with the usual care group (mean number of cardiologist visits, 1.2 vs 1.6; $P=.09$). Those patients who were readmitted had fewer mean number of cardiologist visits than those who were not readmitted ($P=.03$).

The CM kept a log during the first, middle, and last 4 weeks of the recruitment period of how much time was spent with each patient during the 12-week study period. Thus, the average cost of the intervention was calculated based on an hourly wage (including benefits) of \$33.93 for the CM. The average intervention cost per patient was \$228.52, and the average time spent with each intervention patient was 6.7 hours per 12 weeks.

COMMENT

In this study's more heterogeneous population, the case management intervention significantly improved adherence to the treatment plan and patient satisfaction in a cost-effective manner, but it did not have a significant

effect on total readmission rate or increase in medication dosage. Although most previous studies have shown that CHF case management strategies reduce hospital readmissions, the investigators cannot conclude that case management is invariably effective. Subgroup analyses in this and previous studies^{23,30} help bring the current findings into context with most previous study results.

CM-PHYSICIAN RELATIONSHIP

Analysis of the subgroup of study patients who received their postdischarge care from local cardiologists and lived in the study hospital area reveals differential intervention effects that mirror those shown in several other positive studies. Among this subgroup, the intervention significantly decreased the CHF readmission rate (1 [2%] of 50 in the intervention group vs 7 [14%] of 49 in the usual care group, $P=.03$), possibly a result of the CM having ready access to communication with these patients' cardiologists via e-mail, via telephone, or directly in person. Accordingly, the case management program and the CM were familiar to and trusted by these cardiologists and could thus play a larger role in this subgroup's postdischarge course of care. This strong and trusted relationship between the cardiologist and CM also translated into cost savings, preventing 6 readmissions and saving an estimated \$54 000. The networked environment and strong physician-CM relationship appear to have outweighed the heterogeneous aspects of this subgroup, underscoring the importance of such relationships in today's complex care process.

Other studies that have shown a positive effect on readmissions had more formally integrated physician networks, where greater control of care could occur for all study patients. In some, patients were excluded if they were receiving follow-up care outside the study hospital or catchment areas.^{7,31-33} In contrast, the current study had a patient population that was cared for by 59 different attending physicians during their hospitalization and 156 different physicians (cardiologists, internists, or family practitioners) during follow-up care, all of whom were spread throughout northern New York and Vermont. Practitioners were also geographically dispersed (non-networked) to interact with the CM in a consistent, coordinated, and fully trusting manner, except in the subgroup of patients cared for locally and as discussed herein.

Evidence also suggests that sufficient clinic support for physician practices is essential to prevent readmission when exacerbation occurs. In the current study, intervention patients were instructed to call the physician responsible for their CHF care when changes in their symptoms occurred. Patients who called their physician's office to report symptoms were, at times, unable to contact or get immediate attention. Some busy and stressed practices directed patients to the ED rather than immediately seeing the patient in the clinic. Jaarsma et al³⁴ found that changes in the organization of care and intensity of follow-up might be required to prevent unnecessary readmissions. For example, many successful CHF programs^{7,35,36} use a telephone monitoring system as an integral strategy and immediate enhanced access

for patients to see a practitioner at the time symptoms first develop. The varied accessibility to care and the lack of coordinated system supports in an extended, nonnetworked practitioner setting may have limited the effectiveness of this study's intervention.

PATIENT CHARACTERISTICS

Riegel et al,³⁰ in another study that tested case management strategies in a more heterogeneous (unselected) CHF population, also found no overall effect on readmissions. However, when patients were stratified by physical function classification, a significant intervention effect was observed among patients with early physical functional compromise (class II). Thus, case management reduced hospital readmissions only for moderately impaired CHF patients but not for patients without functional impairment (class I) and for those most functionally impaired (class III, IV). Likewise, Rich et al²³ found differential effects on readmission by stratifying for readmission risk. Moderate-risk intervention patients showed the greatest trend toward reduction in readmissions and hospital days vs the high-risk group. Although the current study found no intervention effects that stratified for functional severity or readmission risk, patients in the intervention group with weight gain and chronic renal failure had significantly fewer hospital readmissions (weight gain, $P = .03$; chronic renal failure, $P = .05$). An intervention that emphasizes sodium and fluid recommendations and edema assessment would be expected to show such a result. This is also consistent with other studies^{36,37} in which effectiveness of the intervention was directly related to management of fluid overload. The number of patients with these admitting characteristics is too small to make any generalizations, but it does provide evidence that this intervention may be selectively effective.

Which subgroups of CHF patients would benefit from which case management strategies remains to be more exactly established. The results of the studies by Rich et al²³ and Riegel et al³⁰ stand in contrast to other studies where those with severe and advanced symptomatic heart failure benefited significantly from similar case management interventions.^{10,31,38} Most studies, including this one, have not been powered to support analyses by subgroups. Continued research is needed to more accurately determine the differential benefits of case management strategies by severity, risk for readmission, diverse patient characteristics, and type of follow-up care.

ADHERENCE TO TREATMENT PLAN

Although adherence to the treatment plan was significantly better for the intervention group, there was no corresponding decrease in readmissions. Jaarsma et al³⁴ and Chin and Goldman³⁹ also found that heart failure self-care behavior or patient adherence showed little or no relationship with readmission rate. Similarly, Rich et al⁴⁰ showed that although there was a trend toward fewer readmissions when medication compliance was 90% or

greater, overall, adherence was not predictive of decreased readmissions. The lack of a clear relationship between adherence and readmissions may be understood in several ways.

Adherence to the treatment plan was measured by self-report and so may not have reflected actual behavior but rather patient knowledge of their treatment plan. Michalsen et al²⁴ found that patients' knowledge about their CHF treatment was not associated with better compliance. It was observed in this study and in the study by Michalsen et al that patients continued to delay seeking medical attention when symptoms occurred despite the ongoing education and reinforcement of action to be taken. The CM may have had greater influence to convince patients to seek attention early if a stronger CM-physician relationship had existed and a unified education and treatment plan been presented. Improved behavioral strategies are needed to close this gap between knowledge and adherence behavior.

It is also possible that the fault lies with the treatment plan to which the adherence was improved. The treatment plan may need to be more appropriately tailored to each patient's specific characteristics for adherence to prevent readmissions. As mentioned previously, the current treatment plan, which emphasized sodium and fluid recommendations and edema assessment, reduced readmissions for patients likely to benefit from such emphasis, those with the characteristics of weight gain and the comorbid condition of chronic renal failure.

MEDICATIONS

The intent of case management in this study was to facilitate the use of CHF medications and advancement to target doses. There was a trend toward higher doses of ACEI or ARB in the intervention group after 12 weeks ($P = .08$). As recruitment for this study got under way, it was observed that the hospital's utilization and advancement to target dosages of CHF medications were above average and better than what had been reported in previous studies,³⁰ perhaps a consequence of CHF being a national and statewide health care priority for quality improvement. Although patients were in the hospital, many were titrated to maximum tolerated doses for either ACEI or ARBs and BBs before discharge only to later require titration to lower doses because of renal function issues or hemodynamic adverse effects. So perhaps energy directed toward maximizing medication dosages could have been more effectively spent elsewhere. Again, it is important for future studies to match appropriate interventions to current patient needs.

COST AND PATIENT SATISFACTION

Although the cost analysis did not find statistically significant differences, the cost savings would be considerable when applied to a larger population of CHF patients if the data reflect true rather than chance differences. The significant difference in the patient satisfaction between the control and case managed group also is note-

worthy. Patient satisfaction is a worthwhile outcome for a case management program, especially in today's demanding competitive health care environment.

STUDY LIMITATIONS

One limitation to this study was the inability to blind patients and researchers to group assignment; there was no practicable alternative. Another limitation was the lack of a more consistent application of the NYHA classification tool. Within a week of discharge, patients were called by either the CRC (control group) or the CM (intervention group) and asked a series of questions regarding their symptoms and activity. For both groups, the CM then assigned an NYHA classification score based on the answers given. A more sensitive instrument could have enabled the investigators to more effectively measure differential intervention effects on patients stratified by functional status. To better measure adherence to treatment plan, methods such as detailed weight, food and fluid logs, and pill counts could be more reliable than patient self-report.

CONCLUSIONS

In this study, case management compared with usual care did not lower the 90-day readmission rate of CHF patients possibly due to the more heterogeneous population and more frequently nonnetworked follow-up care setting. This study saw improvement in both patient satisfaction and adherence to treatment plan while at the same time promoting optimal use of CHF medications and cost reductions.

By subgroup, there was a significant decrease in CHF readmissions for intervention patients who resided near the hospital and were cared for by a local cardiologist, where strong working relationships had been built between the CM and cardiologists. In this subgroup, there was consistency with other study results that was lacking for the larger, more heterogeneous study population. In addition, there was also a significant reduction in CHF readmissions for the subgroup of patients initially admitted with chronic renal failure or weight gain. This finding makes sense because the intervention was designed specifically to address CHF issues, including fluid overload.

Combined with evidence from previous studies that show differential intervention effects among subgroups of CHF patients^{23,30,31} and with those that show no such effect,^{12,14,18,30,33-35,41-44} current results suggest that specific case management programs need to be paired with specific patient populations to be effective. Future multiarmed studies might be powered specifically to measure differential effects of case management on CHF patients stratified by severity, CM-physician coordination during follow-up, or predominant symptoms and patient characteristics.

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