Care of Adults With Heart Failure

Patterns of adherence to diuretics, dietary sodium and fluid intake recommendations in adults with heart failure

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ABSTRACT

Background: Three behaviors advocated to minimize fluid-related hospitalizations in patients with heart failure (HF) are restricted sodium and fluid intake and consistent oral diuretic use. Adherence to behaviors intended to decrease risk of hospitalization is believed to vary over time, but surprisingly little research has addressed patterns of adherence in HF patients. Objective: To describe patterns over time of 3 recommended self-care behaviors (i.e., diet, fluid intake, and diuretic dosing) in adults with HF and to determine how time and behavior influenced adherence rates. Methods: We enrolled 24 adults hospitalized for a HF exacerbation and discharged on a loop diuretic into a descriptive, longitudinal pilot study. Over 3-months, diuretic use was measured using electronic event monitoring, and participants were telephoned regularly to assess sodium and fluid intake. Data were summarized for each 2-week intervals. Results: The overall adherence rates were 42.4% for low sodium diet, 96.4% for fluid restriction, and 84.7% for the diuretic regimen. Early after hospital discharge, medication adherence was the highest, and dietary adherence was the lowest, but adherence to diet and diuretic use decreased significantly over time. Conclusion: Although participants were just discharged from the hospital after an acute exacerbation of HF, all three behavioral patterns decreased markedly over the 3-month follow-up period.

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One in 4 heart failure (HF) patients are readmitted to a hospital within 30 days of discharge, and almost half are readmitted within 6 months.[1] Poor treatment adherence is related to hospital admissions,[2−5] so patient education is considered essential prior to hospital discharge,[6] with performance monitored by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO).[7] In spite of this effort, treatment adherence is poor.[8] Medication adherence declines over time[9] and patients struggle to follow diet recommendations.[10] Fluid restriction is becoming less and less common, although it is still included in clinical practice guidelines.[6] However, we actually know relatively little about patterns of adherence across behaviors and over time and whether there is an interaction among the behaviors recommended.[11] Thus, the objective of this pilot study was to describe patterns over time of 3 recommended self-care behaviors (i.e., diet, fluid intake, and diuretic dosing) in adults with HF and to determine how time and behavior influenced adherence rates.

Three behaviors thought to minimize fluid-related hospitalizations in HF patients are restricted sodium and fluid intake along with consistent oral diuretic use.[12] Recognizing the links between sodium intake and fluid retention,[4,13] patients with HF are routinely advised to follow a low sodium diet to avoid hospitalization.[14−16] There are insufficient data to support a specific sodium recommendation,[17] and aggressive restriction is not helpful,[18] but a 3 g dietary sodium restriction is probably judicious for HF patients.[3] Yet, numerous studies have shown that adherence to dietary sodium restriction is poor in patients with HF.[10,19−21]

Fluid limitation is no longer routine for every person with HF, but a tailored fluid restriction based on body weight (30 ml/kg per day) has been advocated as reasonable.[22] In those advanced HF patients who continue to progress and develop persistently severe symptoms despite maximum guideline driven medical therapy, a fluid intake restriction of 1.5−2 liters/day is advocated.[6] Temporary fluid restriction is considered in persons with decompensated HF and those with hyponatremia.[22]

Relatively little attention has been given to diuretic use.[23] Diuretics have been shown to improve symptoms and exercise tolerance

in patients with HF,[24] and are advocated for all patients with evidence of fluid retention.[6] However, patients commonly delay or skip diuretic doses when toileting is inconvenient, which has been associated with cardiovascular- and HF-related hospitalizations.[25] Together these studies suggest that all three behaviors have a role in preventing HF-related hospitalization and are important to recommend in patients with HF.

Factors associated with poor adherence to behavioral recommendations for HF patients have been studied in a wide variety of samples.[26−29] Yet, there is little evidence regarding who is most likely to be consistently adherent over time in any patient population. The study of personality traits would suggest that individuals have consistent behavioral patterns,[30] yet others have found that illness behavior is dynamic and changes in response to situational factors.[31] In previous studies we identified changes in overall self-care maintenance and management patterns over time,[32,33] but differences among specific behaviors and their consistency over time have not been described.

Simon and colleagues[34] studied adherence to treatment for depression across different treatment episodes and different treatment methods (i.e. medication and psychotherapy). They found a gradation of increasingly consistent treatment adherence, with moderate consistency across treatments and the highest consistency within the same treatment over time. This pattern suggests that early adherence to a treatment predicts adherence over time. No studies of this nature were located in HF patients, but knowing how well early adherence predicts adherence over time would have implications for research and clinical practice. Thus, in this pilot study we examined patterns of sodium intake, fluid intake, and oral diuretic use over time in adults with HF and tested how time and behavior influenced adherence rates. We hypothesized that adherence would differ over time between any two behaviors (sodium and fluid intake adherence and diuretic use).

Methods

Using a descriptive, longitudinal design, we enrolled a convenience sample of 24 patients hospitalized for HF and followed them for 3 months, collecting data every 2 weeks. Adherence patterns were analyzed at the end of 3 months. As this was a pilot study, we did not estimate sample size power but instead continued to collect data until we had a sample that represented the typical population of patients hospitalized at this institution. A total of 118 observations were available for analysis.

Sample

Adults with chronic HF were enrolled following hospitalization for an acute exacerbation of HF regardless of HF type (reduced or preserved ejection fraction). These patients had been hospitalized in a large teaching hospital in the Northeastern U.S. Patients with HF are typically admitted to specific units where the nurses are experienced in the care of individuals with HF. The nurses routinely teach patients about the importance of treatment adherence after hospital discharge and the behaviors that are important to adopt. We enrolled only those who were discharged on a loop diuretic, able to speak English, and living in an independent setting where medications were self-administered and dietary choices were available. Exclusion criteria included medical instability (e.g. patients who were critically ill), listed for cardiac transplantation, major untreated psychiatric illness, inadequate health literacy, and cognitive impairment. Health literacy was assessed with three brief questions shown to be effective for identifying poor health literacy.[35] Anyone reporting that they always or often have problems learning about their medical condition because of difficulty understanding written information were

excluded. Cognitive impairment was screened using the Telephone Interview for Cognitive Status (TICS).[36] Validity of the TICS was demonstrated with comparisons to the Mini-Mental State Exam and discrimination between persons with dementia and normal controls.[36] Anyone with a TICS score <25 was ineligible.

Procedure

The study was approved by the Institutional Review Board of the University of Pennsylvania. All participants provided informed consent. Baseline data were obtained during a home visit conducted by research staff typically within two weeks (13 ± 11.2 days) after hospital discharge. During this visit, participants were taught how to use the medication electronic monitoring (EM) device, maintain records related to the EM device in a research diary, and estimate fluid intake (e.g., glass and cup sizes). Participants were told to expect phone calls every two weeks from a research assistant (RA). During these calls the RA queried participants about use of the EM device and their intake of high sodium foods and fluids, as described below. At 3-months we picked up the EM and research diaries during a face-to-face meeting, and downloaded diuretic usage data from the prior three months. All study data were managed using Research Electronic Data Capture (REDCap).[37]

Measurement

Dietary sodium is unreliably judged by self-report,[38] so participants were telephoned every two weeks to ask about their intake of foods particularly high in sodium. Research assistants read a checklist of 24 foods, sauces, and medicines documented to be high in sodium. Examples of items on the list included potato chips, soy sauce, and effervescent tablets. The list was developed by the investigators from existing educational materials (e.g. *How to Follow a Low Sodium Diet* module from the Heart Failure Society of America). The list was read quickly and participants responded with yes or no regarding ingestion of the item in the past week. If yes, the number of times an item had been eaten in a week was noted. If a single food item was eaten repeatedly, it was counted each time the food item was eaten. One week was used because others have shown that dietary patterns are fairly stable,[39] and we wanted to minimize issues of recall and avoid missing data from patients avoiding our phone calls.

Fluid intake was assessed every 2 weeks. A complex array of factors influences the opportunity to drink fluids and opportunity influences intake, but HF patients may have less variability in opportunity than well individuals. Thus, a 24-hour period was used to minimize issues of recall. Participants were taught how to measure fluid intake using their own cups, glasses, and bowls. For example, volume of the cup used to drink a morning beverage such as coffee or tea was measured by the RA, who noted it on the patient's diary (e.g., 1 cup). Patients were not required to track their fluid intake daily so the prior 24-hour period was used for convenience. Staff did not specify a desirable fluid intake.

Diuretic use was assessed using a medication event monitoring system (MEMSCap, Aardex, Switzerland). Microelectronic chips in the caps of medication containers document each time that the cap is removed from a medication vial. Real-time data were collected in the device and later downloaded and integrated with other data for analysis. Cross-validation studies show that EM is more sensitive, reliable and valid than other measurement techniques such as pill counts, biochemical assays, collateral reports, or clinical judgment.[40] Percentage of prescribed doses taken was calculated for each 2 week period.

Sociodemographic characteristics, number of medications taken daily, HF duration, and sufficiency of social support were self-reported. Clinical characteristics and comorbid conditions were abstracted from the electronic medical record. New York Heart

Association (NYHA) class was assessed at enrollment using a standardized interview.[41] A single cardiologist rated NYHA in all participants.

Analysis

We tested the hypothesis that adherence would differ over time between any two behaviors (sodium and fluid intake adherence and diuretic use). Analysis began by categorizing participants as adherent or not to each of the 3 behaviors for each 2-week period. For sodium intake, clinical practice guidelines recommend that clinicians recommend some degree (e.g.,<3 g) of sodium restriction to their patients with HF.[6] After examining the sodium content of the foods on the list, three experts in HF (1 PhD prepared HF nurse, 1 experienced nurse clinician, 1 cardiologist) discussed how many high sodium food items they would consider to be problematic for someone with HF. For example, 1 serving of Campbell's soup contains 360 − 600 mg of sodium per serving and 1 tablespoon of soy sauce contains 879 mg of sodium. Based on this type of analysis, the three experts agreed that more than 6 servings per day would probably exceed a 3 g sodium diet. An appropriate fluid intake was calculated using a formula of 30 ml per 1 Kg dry body weight obtained on hospital discharge.[42] The only exception was patients who were NYHA class IV; their maximum fluid intake was 2000 ml/day. Participants were considered nonadherent to their fluid restriction if they drank more than their individual cut-point. Adequate adherence to the diuretic regimen was considered a minimum of 80% of prescribed doses taken.[43] Each behavior was scored as adherent or nonadherent at each measurement interval, for a maximum of 18 separate ratings for each person (3 behaviors, 6 time periods). Then the rate of adherence to each behavior at every follow-up interval was calculated and graphed to visualize trends over time.

All statistical analyses were considered exploratory and performed using STATA version 15 (College Station, TX), with the significance level set at $\alpha = 0.05$ using a two-tailed test. Any significant results were considered preliminary and will need to be confirmed by a larger more comprehensive study. Sociodemographic and clinical data were analyzed with descriptive statistics. To compare adherence among the three treatment behaviors at each time point, pairwise within subject sign tests were used. To show linear relationships between time and adherence rates for three different behaviors, multiple regression analyses were conducted. Two multiple linear regression models were built to examine how time (*week*) and *behavior* (i.e., diet, fluid, and diuretic dosing) influenced adherence rates. In the first model, we included time and each behavior as independent predictors to examine consistency of each treatment adherence rate over time. When we allowed interaction terms between *Week* and *Behavior* in the second model, the differences among the three behaviors depended on the effects of time, indicating that time inconsistently influenced each treatment adherence rate. The two regression models were compared using a likelihood-ratio test.

Results

We enrolled 24 participants. The sample was relatively young for a HF sample (mean age 59.2 ± 9.2 years) and predominately male. More than half were married or living with a partner and receiving sufficient social support. The mean TICS score on enrollment was 31 ± 4.0, indicating intact cognition. Participants had many comorbid conditions (mean number 7.4 ± 3.0) and took an average of 12.5 ± 4.4 medications daily. Most had HF with reduced ejection fraction and 70% of participants were NYHA class III or IV (Table 1). Health literacy was sufficient for enrollment, although 3 participants reported some difficulty understanding written information and 5 reported sometimes or often needing someone (like a family member) to help them

Table 1
Sociodemographic and clinical characteristics of the enrolled sample (*N* = 24)

	Mean ± SD
Age in years	59.2 ± 9.2
Social status (possible range 8−66; higher score = higher social status)*	39.9 ± 9.1
HF duration in years, self-reported	4.8 ± 5.4
Total number of comorbid conditions	7.4 ± 3.0
Total number of daily drugs taken	12.5 ± 4.4
	Frequency (%)
Male sex	16 (66.7%)
Race/ethnicity	
Black	10 (41.7%)
White	12 (50.0%)
Other (American Indian/Alaskan native, Mixed Race)	2 (8.3%)
Marital status	
Married or living with partner	13 (54.2%)
Single, divorced or separated	9 (37.5%)
Widowed	2 (8.3%)
Highest level of education	
Less than high school	2 (8.3%)
High school or Trade school	8 (33.4%)
Some college or college degree	12 (50.0%)
More than college degree	2 (8.3%)
Financial income	
Comfortable, have more than enough to make ends meet	6 (25.0%)
Have enough to make ends meet	12 (50.0%)
Do not have enough to make ends meet	5 (20.8%)
No response	1 (4.2%)
Employment	
Employed full or part-time outside of the home	8 (33.3%)
Unemployed	2 (8.4%)
Sick leave or disability	5 (20.8%)
Retired	8 (33.3%)
Other	1 (4.2%)
Has someone in whom to confide	23 (95.8%)
Quality of support	
Satisfactory	1 (4.2%)
Good	5 (20.8%)
Very good	18 (75.0%)
HF type	
Systolic (HFrEF) or mixed	16 (66.7%)
Diastolic (HFpEF)	8 (33.3%)
NYHA Class	
Class II	7 (29.2%)
Class III	12 (50.0%)
Class IV	5 (20.8%)

* Socio-economic status was assessed using the Barratt Simplified Measure of Social Status.[53]

read hospital materials. Only 2 individuals reported both issues. No one reported lack of confidence in filling out medical forms by himself/ herself. During the three-month follow-up period, 1 patient visited the Emergency Department, none had an unplanned physician visit, 4 were rehospitalized for HF, and 2 died.

All pairwise within subject comparisons among the three treatment adherence behaviors are presented in Table 2. There were significant differences in adherence between diet and medication at each follow-up period until two months. Although diet adherence significantly differed from fluid adherence at all follow-up times, no difference between fluid and medication adherence was found from week 2 to week 12.

A common pattern, overall, was poor dietary adherence yet excellent fluid adherence and good diuretics adherence. The overall adherence rates were 42.4% for low sodium diet, 96.4% for fluid restriction, and 84.7% for the diuretic regimen. Fig. 1 illustrates how adherence rates changed over time for each behavior. At week 2, early after hospital discharge, medication adherence was the highest (95.5%) and dietary adherence was the lowest (45.5%). Each adherence rate fluctuated, but the overall trends in treatment adherence rates decreased over time, with significant declines in diet (16.1% point) and medication adherence (22.8% point).

Table 2
Pairwise within subject treatment adherence comparisons by week

Time	Diet − Medication				Diet − Fluid				Fluid − Medication			
	+	−	0	p value	+	−	0	p value	+	−	0	p value
Week 2	1	10	9	0.012*	1	11	9	0.006**	1	1	17	1.000
Week 4	2	10	8	0.039*	0	10	10	0.002**	2	0	17	0.500
Week 6	1	11	8	0.006**	0	11	8	0.001**	2	0	17	0.500
Week 8	1	10	8	0.012*	0	9	9	0.004**	2	1	15	1.000
Week 10	2	8	9	0.109	0	8	10	0.008**	4	1	13	0.375
Week 12	2	9	6	0.065	0	10	6	0.002**	5	1	10	0.219

Note: This table shows that differences in adherence among 3 behaviors at the individual level. For example, comparing adherence to diet with medication adherence at week 2, only 1 participant was adherent to diet, but not to diuretics. However, 10 participants were nonadherent to diet, but adherent to the diuretics. Interestingly, 9 participants were either adherent to both diet and diuretics or nonadherent to both. The comparison of adherence between fluid and medication at week 2, there was no difference in adherence for 17 participants. They were either adherent to both fluid and medication or nonadherent to both. A small p-value indicates that there is a statistically significant difference in treatment adherence between two behaviors.

* $p < 0.05$.

** $p < 0.01$.

The overall fit of the first regression model was excellent ($p < 0.001$, $R^2 = 0.9723$). The coefficients for *Week* and *Behavior* (diet, fluid, and medication) were statistically significant ($p < 0.01$). Although the second model fit the data well ($p < 0.001$, $R^2 = 0.9792$), none of the coefficients of the interaction terms between time and each behavior was statistically significant (Table 3). Based on the model comparison test result (Log likelihood ratio $\chi^2 = 5.17$, $p = 0.076$), the simpler model without interaction terms had a slightly better fit. In this model, the three different behaviors shared the same slope, meaning that the amount by which adherence rate (%) changed for each week was the same across behaviors. The y intercepts differed, in other words, each treatment adherence rate began at a different point; however, all three treatment adherence rates decreased consistently over time (Fig. 2).

Discussion

The objective of this pilot study was to examine patterns among 3 self-care behaviors (adherence to dietary sodium restriction, fluid intake restriction, and diuretics) over time in adults with HF. We found that adherence to these three behaviors was vastly different, suggesting that patients pick and choose among our recommendations. We also found that adherence to each behavior fluctuated over time, but overall, treatment adherence decreased rapidly after hospitalization for an exacerbation of HF. This finding calls into question the assumption of providers that patient education during hospitalization is effective in influencing patient adherence of adults with HF after hospital discharge.

We saw that patients commonly were poor in dietary adherence yet excellent in fluid adherence and good in diuretic adherence.
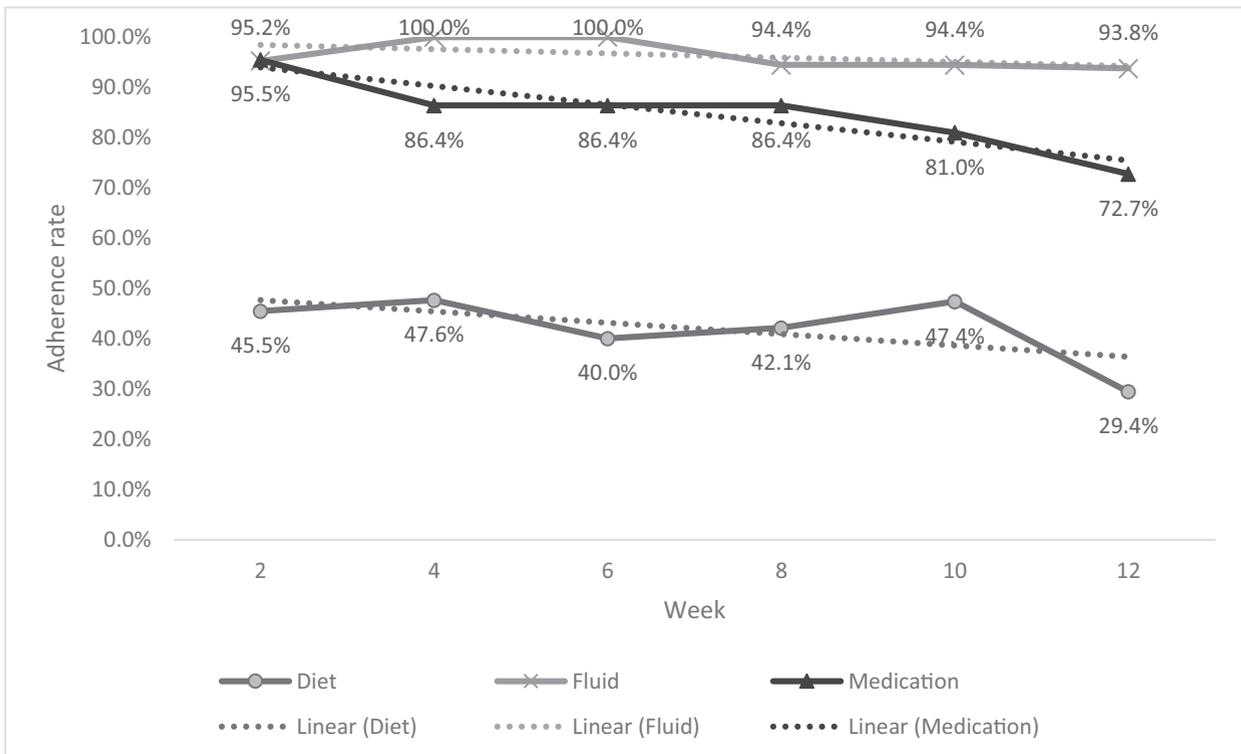

Fig. 1. Trends of adherence rates. Dotted line shows trends.

Table 3
Multiple linear regression models predicting treatment adherence rate

	Model 1a	Model 1b	Model 1c	Model 2a	Model 2b	Model 2c
Week	−1.14** (0.31)	−1.14** (0.31)	−1.14** (0.31)	−1.13* (0.51)	−0.42 (0.51)	−1.86** (0.51)
Diet	*Base*	−54.32*** (2.62)	−42.71*** (2.62)	*Base*	−49.40*** (5.58)	−47.81*** (5.58)
Fluid	54.32*** (2.62)	*Base*	11.61** (2.62)	49.40*** (5.58)	*Base*	1.59 (5.58)
Medication	42.71*** (2.62)	−11.61** (2.62)	*Base*	47.81*** (5.58)	−1.59 (5.58)	*Base*
Week × Diet				*Base*	−0.70 (0.72)	0.73 (0.72)
Week × Fluid				0.70 (0.72)	*Base*	1.43 (0.72)
Week × Medication				−0.73 (0.72)	−1.43 (0.72)	*Base*
Constant	49.94 (2.87)	104.26 (2.87)	92.65 (2.87)	49.88 (3.95)	99.28 (3.95)	97.69 (3.95)
R^2	0.9723***			0.9792***		

Note: Model 1a, 1b, and 1c were the same model with a different reference category; Model 2a, 2b, and 2c were the same model with a different reference category; Coefficients (standard errors) were reported;

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Others have demonstrated that a significant proportion of HF patients adhere poorly to a low sodium diet,[19] as we found in this study. It may be that patients are not aware that they are eating a diet high in sodium. Others have found that a significant portion of patients who were eating more than 10 grams of sodium per day thought that their salt intake was low.[44] Others have found that patients who intend to follow dietary recommendations have misconceptions about sodium[45,46] or serving size.[45] Another explanation is that it is difficult to modify dietary preferences learned as children. Children prefer sweet and salty tastes over the bitter tastes of low-sugar, low-sodium, vegetable-rich diets.[47] If healthy dietary preferences are not developed in childhood, adults will have great difficulty adhering to a diet that is low in sodium.

We were surprised that overall diuretic adherence (84.7%) was good, although it decreased over time. Viana and colleagues[48] found that only 69.8% of 297 patients with HF adhered to loop diuretics. In a review of medication adherence in HF, Wu and colleagues found that most investigators have found nonadherence rates of 40%−60% of HF patients.[49] Our results may differ from these prior results because we enrolled primarily multimorbid patients with NYHA class III or IV HF. It may be that sicker patients see more need for medications and are more adherent than patients with less severe illness.

Most participants in our study limited fluids, but we do not know if this is in response to recommendations. They may simply not be drinking much, as others have found in healthy populations.[50] Others have found that thirst significantly predicts adherence to fluid restriction,[22] but unfortunately we did not query patients about this symptom so we are unable to explain the high adherence further.

The variability in treatment adherence supports what we have seen repeatedly in psychometric testing of the Self-Care of Heart Failure Index (SCHFI).[52] The Self-Care Maintenance scale of the SCHFI measures adherence with various behaviors (e.g., medication taking,

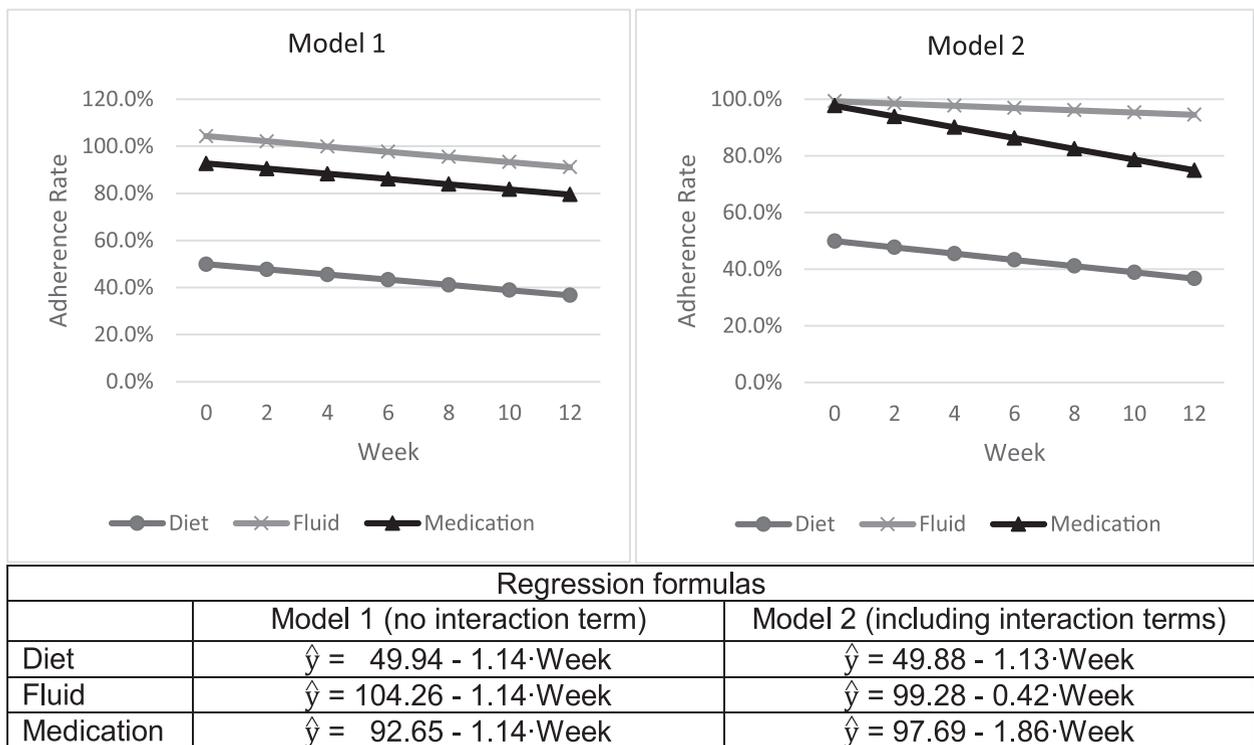| Regression formulas		
	Model 1 (no interaction term)	**Model 2 (including interaction terms)**
Diet	$\hat{y} = 49.94 - 1.14 \cdot \text{Week}$	$\hat{y} = 49.88 - 1.13 \cdot \text{Week}$
Fluid	$\hat{y} = 104.26 - 1.14 \cdot \text{Week}$	$\hat{y} = 99.28 - 0.42 \cdot \text{Week}$
Medication	$\hat{y} = 92.65 - 1.14 \cdot \text{Week}$	$\hat{y} = 97.69 - 1.86 \cdot \text{Week}$

Fig. 2. Two multiple linear regression models on treatment adherence rates. In the first model without interaction terms between time and each behavior, the effect of *Week* on adherence rate was the same across behaviors (3 parallel regression lines). In other words, the differences in adherence rates among the 3 behaviors were constant over time (from week 2 to 12). The coefficient of *Week* (slope, −1.14) represented the amount by which adherence rate (%) changed for each week; *y* intercepts showed the expected adherence rates at week 0.

exercise, and sodium restricted diet). But in reliability testing, this scale often demonstrates borderline internal consistency. The results of this study demonstrate what we have always suspected — the behaviors we recommend are not indicators of a single concept. Patients appear to judge some behaviors as worthy of adherence and others as voluntary.

Further research is needed to understand how patients make decisions about which recommendations to adopt. The high diuretic adherence coupled with the low dietary adherence suggests that patients may be actively balancing the two behaviors. If this hypothesis is supported in future study, the finding would demonstrate a high level of decision-making that is rarely acknowledged in adherence research. Knowledge would be needed to make such high level decisions, but a recent systematic review that found that comprehension is poor among hospitalized patients and patients often overestimate their knowledge.[51]

This pilot study had several limitations. The primary limitation was the small sample size, although the repeated measurement of data over time countered this issue to some degree. The list of high sodium foods used was self-report. Although the list had content validity it has not yet been validated against objective measures such as urinary sodium. The measure of fluid intake was dependent upon participant judgments, but they were carefully trained in person to provide accurate estimates. Another limitation is that the frequency of data collection might have changed adherence patterns, although we did not see evidence of such a change. A strength of the study was that we demonstrated that the methods developed for use in this pilot study are feasible, which can inform a larger scale investigation testing this hypothesis.

The clinical implication of this study is that an acute hospitalization is not sufficiently salient to motivate HF patients to adhere to recommended behaviors. We cannot assume that hospitalized patients are listening carefully to our instructions regarding how to avoid a future hospitalization. Another clinical implication is that a low-sodium diet appears to be particularly difficult for patients to follow. Telling patients that they need to limit sodium in the diet is clearly insufficient, so better ways to help patients modify their diets are clearly needed. Advanced methods of motivating adherence (e.g. motivational interviewing) and the time to use such methods in clinical practice are needed.

In conclusion, our results suggest that adherence to diet and diuretics declines rapidly after hospital discharge in adults with HF. Patients appear to choose behaviors in which to engage, so dietary sodium and diuretic use patterns should be assessed individually and repeatedly over time.

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Funding

Procedure

The study was approved by the Institutional Review Board of the University of Pennsylvania.

References

1. Desai AS, Stevenson LW. Rehospitalization for heart failure: predict or prevent? *Circulation*. 2012;126(4):501–506.
2. Bennett SJ, Huster GA, Baker SL, et al. Characterization of the precipitants of hospitalization for heart failure decompensation. *Am J Critical Care*. 1998;7(3):168–174.
3. Lennie TA, Song EK, Wu JR, et al. Three gram sodium intake is associated with longer event-free survival only in patients with advanced heart failure. *J Cardiac Failure*. 2011;17(4):325–330.
4. Arcand J, Ivanov J, Sasson A, et al. A high-sodium diet is associated with acute decompensated heart failure in ambulatory heart failure patients: a prospective follow-up study. *Am J Clin Nutrition*. 2011;93(2):332–337.
5. Paterna S, Parrinello G, Cannizzaro S, et al. Medium term effects of different dosage of diuretic, sodium, and fluid administration on neurohormonal and clinical outcome in patients with recently compensated heart failure. *Am J Cardiol*. 2009;103(1):93–102.
6. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am College Cardiol*. 2013;62(16):e147–e239.
7. Organizations. JCoAoH. *Specifications Manual For National Hospital Quality Measures: Heart Failure-1*. Washington, DC: Joint Commission on Accreditation of Healthcare Organizations; 2006.
8. Turrise S. Illness Representations, treatment beliefs, medication adherence, and 30-day hospital readmission in adults with chronic heart failure: a prospective correlational study. *J Cardiovasc Nurs*. 2016;31(3):245–254.
9. Juarez DT, Williams AE, Chen C, et al. Factors affecting medication adherence trajectories for patients with heart failure. *Am J Manag Care*. 2015;21(3):e197–e205.
10. Basuray A, Dolansky M, Josephson R, et al. Dietary sodium adherence is poor in chronic heart failure patients. *J Cardiac Failure*. 2015;21(4):323–329.
11. Ory MG. The resurgence of self-care research: addressing the role of context and culture. *J Cross Cult Gerontol*. 2008;23(4):313–317.
12. Philipson H, Ekman I, Forslund HB, Swedberg K, et al. Salt and fluid restriction is effective in patients with chronic heart failure. *Eur J Heart Fail*. 2013;15(11):1304–1310.
13. Bennett S, Huster G, Baker S, et al. Characterization of the precipitants of hospitalization for heart failure decompensation. *Am J Critical Care*. 1998;7(3):168–174.
14. Neily JB, Toto KH, Gardner EB, et al. Potential contributing factors to noncompliance with dietary sodium restriction in patients with heart failure. *Am Heart J*. 2002;143(1):29–33.
15. Arcand JA, Brazel S, Joliffe C, et al. Education by a dietitian in patients with heart failure results in improved adherence with a sodium-restricted diet: a randomized trial. *Am Heart J*. 2005;150(4):716.
16. Rouse GW, Albert NM, Butler RS, et al. A comparative study of fluid management education before hospital discharge. *Heart Lung*. 2016;45(1):21–28.
17. Gupta D, Georgiopoulou VV, Kalogeropoulos AP, et al. Dietary sodium intake in heart failure. *Circulation*. 2012;126(4):479–485.
18. Doukky R, Avery E, Mangla A, et al. Impact of dietary sodium restriction on heart failure outcomes. *JACC Heart Failure*. 2016;4(1):24–35.
19. Masterson Creber R, Lee CS, Lennie TA, Topaz M, Riegel B. Using growth mixture modeling to identify classes of sodium adherence in adults with heart failure. *J Cardiovas Nurs*. 2014;29(3):209–217.
20. Frediani JK, Reilly CM, Higgins M, Clark PC, Gary RA, Dunbar SB. Quality and adequacy of dietary intake in a southern urban heart failure population. *J Cardiovascr Nurs*. 2013;28(2):119–128.
21. Nieuwenhuis MM, van der Wal MH, Jaarsma T. The body of knowledge on compliance in heart failure patients: we are not there yet. *J Cardiovasc Nurs*. 2011;26(1):21–28.
22. Johansson P, van der Wal MH, Stromberg A, Waldreus N, Jaarsma T. Fluid restriction in patients with heart failure: how should we think? *Eur J Cardiovasc Nurs*. 2016;15(5):301–304.
23. Molloy GJ, O'Carroll RE, Witham MD, McMurdo ME. Interventions to enhance adherence to medications in patients with heart failure: a systematic review. *Circ Heart Failure*. 2012;5(1):126–133.
24. Parrinello G, Torres D, Paterna S, et al. Early and personalized ambulatory follow-up to tailor furosemide and fluid intake according to congestion in post-discharge heart failure. *Internal Emergency Med*. 2013;8(3):221–228.
25. Chui MA, Deer M, Bennett SJ, et al. Association between adherence to diuretic therapy and health care utilization in patients with heart failure. *Pharmacotherapy*. 2003;23(3):326–332.
26. Bidwell JT, Vellone E, Lyons KS, et al. Determinants of Heart Failure Self-Care Maintenance and Management in Patients and Caregivers: A Dyadic Analysis. *Res Nurs Health*. 2015;38(5):392–402.
27. Tsai PK, Wang RH, Lee CS, Tsai LM, Chen HM. Determinants of self-care decision-making in hospitalised patients with heart failure. *J Clin Nurs*. 2015;24(7-8):1101–1111.
28. Siabani S, Driscoll T, Davidson PM, Najafi F, Jenkins MC, Leeder SR. Self-care and its predictors in patients with chronic heart failure in Western Iran. *J Cardiovasc Nursing*. 2016;31(1):22–30.
29. Riegel B, Lee CS, Albert N, et al. From novice to expert: confidence and activity status determine heart failure self-care performance. *Nurs Res*. 2011;60(2):132–138.
30. Fajkowska M, Kreitler S. Status of the trait concept in contemporary personality psychology: are the old questions still the burning questions? *J Pers*. 2018;86(1):5–11.

31. Silverman M, Nutini J, Musa D, King J, Albert S. Daily temporal self-care responses to osteoarthritis symptoms by older African Americans and whites. *J Cross Cult Gerontol*. 2008;23(4):319–337.

32. Pancani L, Ausili D, Greco A, Vellone E, Riegel B. Trajectories of self-care confidence and maintenance in adults with heart failure: a latent class growth analysis. *Int J Behav Med*. 2018;25(4):399–409.

33. Lee CS, Mudd JO, Hiatt SO, Gelow JM, Chien C, Riegel B. Trajectories of heart failure self-care management and changes in quality of life. *Eur J Cardiovasc Nurs*. 2015;14 (6):486–494.

34. Simon GE, Peterson D, Hubbard R. Is treatment adherence consistent across time, across different treatments and across diagnoses? *Gen Hospital Psychiatry*. 2013;35 (2):195–201.

35. Chew LD, Bradley KA, Flum DR, Cornia PB, Koepsell TD. The impact of low health literacy on surgical practice. *Am J Surg*. 2004;188(3):250–253.

36. Brandt J, Folstein M. *Telephone Interview for Cognitive Status*. Psychological Assessment Resources, Inc; 2003.

37. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inf*. 2009;42 (2):377–381.

38. Colin-Ramirez E, McAlister FA, Woo E, Wong N, Ezekowitz JA. Association between self-reported adherence to a low-sodium diet and dietary habits related to sodium intake in heart failure patients. *J Cardiovasc Nurs*. 2015;30(1):58–65.

39. Judd SE, Letter AJ, Shikany JM, Roth DL, Newby PK. Dietary patterns derived using exploratory and confirmatory factor analysis are stable and generalizable across race, region, and gender subgroups in the REGARDS study. *Front Nutrition*. 2014;1:29.

40. Burnier M, Wuerzner G, Struijker-Boudier H, Urquhart J. Measuring, analyzing, and managing drug adherence in resistant hypertension. *Hypertension*. 2013;62 (2):218–225.

41. Kubo S, Schulman S, Starling R, Jessup M, Wentworth D, Burkhoff D. Development and validation of a patient questionnaire to determine New York Heart Association Classification. *J Cardiac Failure*. 2004;10(3):228–235.

42. Holst M, Stromberg A, Lindholm M, Willenheimer R. Description of self-reported fluid intake and its effects on body weight, symptoms, quality of life and physical capacity in patients with stable chronic heart failure. *JClin Nurs*. 2008;17 (17):2318–2326.

43. Nieuwlaat R, Wilczynski N, Navarro T, et al. Interventions for enhancing medication adherence. *Cochrane Database Syst Rev*. 2014;(11). Cd000011.

44. Ohta Y, Ohta K, Ishizuka A, et al. Awareness of salt restriction and actual salt intake in hypertensive patients at a hypertension clinic and general clinic. *Clinical Expe Hypertens (New York, NY: 1993)*. 2015;37(2):172–175.

45. Gary R. Self-care practices in women with diastolic heart failure. *Heart Lung*. 2006;35(1):9–19.

46. van der Wal MH, Jaarsma T, Moser DK, van Gilst WH, van Veldhuisen DJ. Qualitative examination of compliance in heart failure patients in The Netherlands. *Heart Lung*. 2010;39(2):121–130.

47. Mennella JA. Ontogeny of taste preferences: basic biology and implications for health. *Am j clinl Nutrition*. 2014;99(3):704s–711s.

48. Viana M, Laszczynska O, Mendes S, et al. Medication adherence to specific drug classes in chronic heart failure. *J Managed Care Specialty Pharmacy*. 2014;20 (10):1018–1026.

49. Wu J, Moser D, Lennie T, Burkhart P. Medication adherence in patients who have heart failure: a review of the literature. *Nurs Clin N Am*. 2008;43:133–153.

50. Malisova O, Athanasatou A, Pepa A, et al. Water intake and hydration indices in healthy European adults: the European Hydration Research Study (EHRS). *Nutrients*. 2016;8(4):204.

51. Sommer AE, Golden BP, Peterson J, Knoten CA, O'Hara L, O'Leary KJ. Hospitalized patients' knowledge of care: a systematic review. *J Gen Intern Med*. 2018;33 (12):2210–2229.

52. Riegel B, Barbaranelli C, Carlson B, et al. Psychometric testing of the revised self-care of heart failure index. *J Cardiovasc Nurs*. 2018.

53. Barratt W. The Barratt Simplified Measure of Social Status. 2006; http://wbarratt.indstate.edu/socialclass/Barratt_Simplifed_Measure_of_Social_Status.pdf. Accessed January 25, 2014.