Heart Failure Patients Receiving ACEIs/ARBs were Less Likely to be Hospitalized or to Use Emergency Care in the Following Year

Judy Ying Chen, Ning Kang, Deborah Taira Juarez, Irina Yermilov, Ronald S. Braithwaite, Krista A. Hodges, Antonio Legorreta, Richard S. Chung

Abstract: Angiotensin-converting enzyme inhibitors (ACEIs) have been shown to decrease morbidity and mortality in heart failure (HF) patients in randomized-controlled trials; observational studies have confirmed this benefit among patients discharged with HF. Investigating the benefit of ACEIs or angiotensin receptor blockers (ARBs) among general HF patients has important implications for quality-of-care measurement and quality initiatives. The objective of this study is to assess the impact of receipt of ACEIs/ARBs among patients with HF on hospitalization, emergency care, and healthcare cost during the following year. Using administrative data, we identified HF patients between 2000 and 2005 in a large health plan ($n = 2,396$ patients). We conducted multivariate analysis to assess the impact of receipt of an ACEI/ARB on likelihood of hospitalization and emergency care, and on total healthcare cost. We found that patients who received ACEIs/ARBs were less likely to be hospitalized (odds ratio [OR] = 0.82, $p < .05$) or use emergency care (OR = 0.82, $p < .05$) in the following year. Receipt of ACEIs/ARBs was not associated with significantly increased cost. Incentivizing the receipt of ACEIs/ARBs in a general population with HF may be a suitable target for pay-for-performance programs, disease management programs, or newer complementary frameworks, such as value-based insurance design.

Background

Heart failure (HF) is a severe chronic illness with high attributable morbidity, mortality, and cost (Jessup et al., 2009). In multiple randomized-controlled trials, angiotensin-converting enzyme inhibitors (ACEIs) have been shown to decrease HF morbidity and mortality (The CONSENSUS Trial Study Group, 1987; Flather et al., 2000; The SOLVD Investigators, 1991, 1992), and angiotensin receptor blockers (ARBs) have been beneficial for those who cannot tolerate ACEI therapy (Granger et al., 2003; Jong, Demers, McKelvie, & Liu, 2002; Pfeffer et al., 2003; Pitt et al., 2000; Ram, 2008). There are many observational studies verifying the clinical benefits of ACEIs among patients discharged with HF, but they have not looked at a broad inventory of utilization measures (e.g., emergency department visits), have not included ARBs, or have mainly focused on a particularly sick population (hospital discharges), rather than a broad cross section of individuals in care (Ahmed, Centor, Weaver, & Perry, 2005; Ahmed, Kiefe, Allman, Sims, & DeLong, 2002; Ahmed, Maisiak, Allman, DeLong, & Farmer, 2003; Gotsman, Rubonivich & Azaz-Livshits, 2008; Grigorian Shamagian et al., 2006; Hess, Preblick, Hill, Plauschinat, & Yaskin, 2009; Johnson, Jin, Quan & Cujec, 2003; Keyhan, Chen, & Pilote, 2007; Pedone, Pahor, Carosella, Bernabei, & Carbonin, 2004; Rochon et al., 2004; Tribouilloy et al., 2008). Indeed, data supporting the benefit of ACEIs or ARBs on the utilization patterns of HF patients in ''real-world'' settings are comparatively sparse, even though comparing cardiovascular care is one of the highest-priority areas for comparative effectiveness research identified by the Institute of Medicine (Initial National Priorities for Comparative Effectiveness Research, 2009). In particular, it is unclear whether the receipt of ACEIs/ARBs reduces hospitalizations and emergency room (ER) visits.

Investigating the benefit of ACEIs/ARBs among HF patients seen in both inpatient and outpatient settings has important implications for quality-of-care measurement and development of incentive programs, such as pay-for-performance (P4P). Because multiple studies have demonstrated that ACEIs/ARBs are underutilized among patients with HF (Bart et al., 1999; Echemann et al., 2000; Edep, Shah, Tateo, & Massie, 1997; Kermani, Dua, & Gradman, 2000; McDermott et al., 1997; Smith et al., 1998; Stafford & Radley, 2003), many different programs have already been adopted by payers to incentivize the prescription of ACEIs/ARBs (e.g., P4P), even though little data support the benefit of the incentivized behavior (ACEI/ARB) in those settings. To infer whether these programs should be expanded or redirected, it is important to ask whether the receipt of ACEIs/ARBs is associated with improved outcomes and utilization measures in ''real-world'' settings.

Keywords
ACEI/ARB
acute utilization
congestive heart failure
cost

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The objective of this study was to assess the impact of filling ≥ 1 prescription of an ACEI/ARB among patients identified with HF on utilization measures that correlate with poor clinical outcomes (hospitalizations and emergency care), using an administrative claims algorithm. Because healthcare costs are increasingly important, we also investigated the impact of ACEI/ARB prescriptions on overall healthcare costs.

Methods

Data and Sample

We used deidentified administrative claims data from a large health plan in Hawaii. This health plan had implemented a physician P4P program that not only incentivized physicians to write at least one prescription for an ACEI/ARB, but also included a concurrent disease management program for HF patients during this time frame (Chung, Chernicoff, Nakao, Nickel, & Legorreta, 2003). Patients ≥ 18 years of age with at least one inpatient HF encounter (ICD-9 diagnosis code(s): 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 428.0, 428.1, 428.20–428.23, 428.40–428.43), two outpatient HF encounters and HF medication (e.g., digoxin, diuretics, etc.), or three HF outpatient encounters within a 1-year period between 2000 and 2005 were identified and followed for at least 1 year (through 2006). Using this algorithm, only 17% of the patients were identified via an inpatient claim. The majority of the HF patients were identified via outpatient encounters. To ensure that we had complete data, we included only patients who were continuously enrolled in medical and pharmacy benefits for at least 2 years. We excluded patients with a contraindication for an ACEI/ARB (i.e., hypotension, hyperkalemia, angioedema, acute renal failure, or those on dialysis). The final sample was comprised of 2,396 patients and encompassed 3,767 patient-years.

Dependent Variables

The outcomes measured included hospitalizations, ER use, and total healthcare cost (USD). To calculate cost, we used the maximum amount the health plan would pay for a specific claim (''allowed'' amount) and the gross domestic product (GDP) index adjusted to 2006 USD.

Main Independent Variables and Covariates

The main independent variable was the incentivized quality care process of the P4P program, the filling of at least one ACEI/ARB prescription within a 1-year period. Covariates included age (<50, 50–65, ≥ 65 years), gender, comorbidity score, medication burden, having seen a cardiologist, baseline acute utilizations, baseline cost, and calendar year. Comorbidity was measured using the Elixhauser comorbidity score, which was calculated using diagnosis codes (Elixhauser, Steiner, Harris, & Coffey, 1998; Healthcare Cost and Utilization Project [HCUP]). HF was excluded as a comorbidity in this cohort. Medication burden was the number of distinct medication types that patients had filled within a 1-year period, excluding ACEIs/ARBs. Based on the distribution of the medication burden, this variable was dichototomized to ≥ 10 medication types (y/n). All outcomes were measured during the year after the covariates/independent variable were defined because the goal was to assess the impact of the covariates/independent variable (i.e., age, gender, receipt of quality care) on outcomes (i.e., hospitalization) and not outcomes on the covariates/independent variable.

Statistical Analyses

Because a single patient generally had multiple years of follow-up, we used patient-year as the unit of analysis. Hierarchical logistic regressions accounting for the nesting of years within patients were utilized to assess the impact of ACEIs/ARBs on hospitalization in the following year while controlling for age, gender, prior hospitalization, medication burden, having seen a cardiologist, comorbidity score, and calendar year. A second hierarchical logistic regression model accounting for the nesting of years within patients was used to assess the impact of ACEIs/ARBs on ER use in the following year, while controlling for age, gender, prior ER use, medication burden, having seen a cardiologist, comorbidity score, and calendar year. Lastly, to assess the impact of ACEIs/ARBs on total healthcare costs in the following year, we used a hierarchical log-transformed linear model accounting for the nesting of years within patients, while controlling for age, gender, medication burden, having seen a cardiologist, comorbidity score, prior healthcare cost, and year. Our hierarchical models did not cluster by hospitals because only 17% were treated by a hospital at baseline. Additionally, we did not cluster by physicians because, on average, many physicians were involved in the care of each patient.

Variables were assessed for collinearity before their inclusion in the multivariate models. The results of the logistic regressions were presented as odds ratios (ORs) with 95% confidence intervals (CIs); the results of the log-transformed linear model were presented as coefficient estimates with 95% CIs. We calculated the adjusted percent of hospitalization and ER use for patients who had filled and had not filled at least one prescription of an ACEI/ARB separately using the multivariate model estimates. SAS® Proprietary Software, Release 9.1 (SAS Institute Inc., Cary, NC) was used for all statistical analyses. A p value $<.05$ was considered to be significant. This study was determined to be research without ''human subjects'' involvement by an independent IRB.

Results

The majority of HF patients were ≥ 65 years of age and male (Table 1). Across all years, over 70% of patients received an ACEI/ARB. Among patients who received at least one prescription of ACEI/ARB, 80% had received five or more scripts. Both comorbidity scores and medication burdens remained stable over the years of the study, ranging from 2.4 to 2.6 and 8.9 to 9.8, respectively. Hospitalization rates rose to a high of 20.3% in 2002, and fell to 15.8% by 2006. ER visits reached a high of 28.7% in 2004, but had decreased to 24.8% in 2006. Over the years, total healthcare cost ranged from US$9,667 to US$12,920, with inpatient and outpatient costs being the largest components.

Patients who received at least one prescription of an ACEI/ARB were significantly less likely to be hospitalized (adjusted percent 26% vs. 30%, OR = 0.82, 95% CI: 0.68–0.99, $p<.05$) or use the ER (adjusted percent 33% vs. 37%, OR = 0.82, 95% CI: 0.70–0.97, $p<.05$) in the following year (Table 2). Other significant predictors of hospitalization included age ≥ 65 years, prior history of hospitalization, filling ≥ 10 prescription drug types, and greater comorbidity score. Similarly, significant predictors of ER use included prior history of ER use, filling ≥ 10 prescription drug types, and greater comorbidity score. Gender was not a significant predictor of either hospitalization or ER use.

Receipt of an ACEI/ARB was not significantly associated with increased total healthcare cost. However, older patients, patients with greater medication burden, patients with more comorbid conditions, and patients with higher baseline healthcare costs were associated with significantly higher healthcare costs in the following year. There was no significant difference in total healthcare cost associated with gender, having seen a cardiologist, or calendar year (Table 3).

Discussion

Our results suggested that HF patients in a ''real-world'' setting who filled at least one prescription of an ACEI/ARB had decreased acute care utilization during the following year. Specifically, this study showed a 13% decrease in the likelihood of hospitalization, and a 19% decrease in the likelihood of emergency care. In addition, when adjusted for factors such as comorbidity, our results suggested that receipt of an ACEI/ARB was not associated with significantly increased total healthcare cost, because the increase in pharmacy expenditures was offset by savings from less inpatient and ER utilization. Additionally, although our algorithm was consistent with the P4P quality measure requiring only one ACEI/ARB prescription, the majority of patients filled five or more prescriptions; these scripts were all included in the cost calculation and did not lead to an increase in healthcare expenditures. This finding is consistent with prior publications, describing interventions such as providing comprehensive diabetes care and colon cancer screening, which have been shown to be cost effective (Eastman et al., 1997; Maciosek, Solberg, Coffield, Edwards, & Goodman, 2006). We found that older patients, patients who were hospitalized in the year prior, patients with high medication burden, and patients with greater comorbidity were more likely to be hospitalized, raising the possibility that the absolute impact of ACEI/ARB prescriptions on utilization may be larger in these groups.

Our results showed a 13% decrease in hospitalization rates in the ACEI/ARB group, whereas large randomized trials have shown decreases of greater magnitude (22–26%; The SOLVD Investigators, 1991; Pfeffer et al.,

Table 1. Characteristics of Heart Failure Patients by Year

	2000 ($n = 719$)	2001 ($n = 614$)	2002 ($n = 636$)	2003 ($n = 633$)	2004 ($n = 581$)	2005 ($n = 584$)	2006 ($n = 532$)
Age <50 (%)	5.6	7.0	7.2	9.3	10.3	10.6	8.5
$50 \leq$ Age < 65 (%)	23.2	25.4	29.1	29.9	31.2	31.3	29.9
Age ≥ 65 (%)	71.2	67.6	63.7	60.8	58.5	58.1	61.7
Female (%)	38.5	39.6	38.2	35.7	38.0	38.5	43.1
Elixhauser comorbidity score (mean ± *SD*)	2.4 ± 1.6	2.4 ± 1.5	2.5 ± 1.5	2.6 ± 1.7	2.6 ± 1.7	2.6 ± 1.5	2.6 ± 1.6
Medication burden[a] (mean ± *SD*)	9.5 ± 4.8	9.3 ± 4.8	8.9 ± 4.9	9.4 ± 4.9	9.8 ± 4.8	9.4 ± 4.7	9.0 ± 4.5
ACEI/ARB use	71.1	71.8	76.6	73.8	78.1	72.8	72.7
Hospitalization (%)	17.9	18.6	20.3	19.1	18.6	15.8	15.8
ER visit (%)	22.1	26.9	26.3	26.2	28.7	24.7	24.8
Total healthcare cost (mean ± *SD*; 2006 USD)	9,667 ± 17,008	10,344 ± 17,560	10,667 ± 16,622	12,852 ± 21,080	12,920 ± 18,126	11,978 ± 18,129	10,947 ± 14,525
Outpatient	2,918 ± 3,372	2,959 ± 4,209	4,119 ± 6,893	5,116 ± 12,472	4,786 ± 7,109	4,679 ± 6,531	4,038 ± 5,309
Inpatient	4,309 ± 15,884	4,820 ± 16,058	4,467 ± 13,971	4,669 ± 15,418	4,885 ± 14,590	4,121 ± 15,234	3,948 ± 12,142
Pharmacy	2,440 ± 1,845	2,565 ± 1,965	2,081 ± 1,702	3,067 ± 2,414	3,249 ± 2,783	3,178 ± 2,628	2,960 ± 2,391
Seeing a cardiologist (%)	60.9	58.6	67.3	67.9	70.2	72.8	70.1

Note. ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; ER = emergency room.

[a]Mean number of unique medications taken by patients during the baseline year, excluding ACEI/ARBs.

Table 2. Impact of Receipt of an ACEI/ARB on Utilization in the Following Year among Heart Failure Patients

	Hospitalization (Y/N) OR (95% CI) ($n = 2{,}396$)	Emergency Room (Y/N) OR (95% CI) ($n = 2{,}396$)
Received ACEI/ARB (reference: no)	0.82 (0.68–0.99)*	0.82 (0.70–0.97)*
Age (reference: <50 years)		
50–64 years	1.07 (0.75–1.52)	0.76 (0.57–1.01)
≥ 65 years	1.74 (1.25–2.43)**	1.26 (0.96–1.66)
Female (reference: male)	0.99 (0.84–1.17)	1.25 (0.96–1.64)
History of hospitalization (reference: no)	1.65 (1.33–2.04)***	—
History of ER utilization (reference: no)	—	2.51 (2.14–2.95)***
≥ 10 drug types (reference: <10 drug types)	1.82 (1.37–2.41)***	1.61 (1.26–2.07)***
Seen by a cardiologist (reference: no)	0.96 (0.81–1.14)	0.96 (0.82–1.11)
Elixhauser comorbidity score	1.15 (1.09–1.21)***	1.06 (1.01–1.11)*
Year (reference: 2005)		
2000	1.26 (0.96–1.65)	1.08 (0.85–1.38)
2001	1.44 (1.10–1.90)**	1.25 (0.97–1.61)
2002	1.25 (0.94–1.64)	1.25 (0.97–1.60)
2003	1.16 (0.88–1.53)	1.16 (0.90–1.49)
2004	1.06 (0.80–1.41)	1.18 (0.91–1.52)

Note. ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; CI = confidence interval; ER = emergency room; OR = odds ratio.
*p value <.05,
**p value <.01,
***p value <.001.

1992). We hypothesized that our observed decline in hospitalizations was more modest because of a dose-response effect (e.g., our patient population was only required to have filled one prescription, whereas, in these randomized trials, patients were closely monitored to ensure that ACEI/ARB's were being taken consistently); however, true differences in magnitude of ACEI/ARB effect between ideal (e.g., efficacy) and real-world (e.g., effectiveness) settings may also have been an important contributor. That said, a 13% decrease in hospitalization demonstrated a substantial utilization effect from a minimal prescription requirement in a real-world setting. Furthermore, there is the possibility that hospitalization rates could be further decreased through more vigilant medication monitoring by physicians.

A previous study by Abarca, Malone, Armstrong, and Zachry (2004) also sought to identify the impact of ACEI in HF managed care patients using administrative claims data. In addition to finding fewer hospitalizations, they also found that total costs were lower in the ACEI group. However, Abarca and colleagues did not include patients on ARBs in the ACEI group, because ARBs are significantly more expensive than ACEIs, this grouping may have offset cost reductions elsewhere more completely in our study. Our study is likely generalizable to a wide range of practice settings, in which ARBs may be readily substituted for ACEIs in patients with contraindications to ACEIs.

Our study has notable limitations. First, the selection bias of patients who received ACEIs/ARBs may have accounted for the results presented. However, our data revealed that, at baseline, patients who received ACEIs/ARBs had higher rates of hospitalization per 1,000 than patients who did not receive ACEIs/ARBs (280 vs. 270, $p < .05$). Thus, this selection bias may have led to an underestimation of the benefits of ACEIs/ARBs, rather than an overestimation. Second, this is an administrative claim-based analysis with potential missing data and erroneous coding. However, the claims algorithm used in this study has captured HF patients with 98% specificity, when compared with a telephone survey of patients in a previously published study (Rector et al., 2004). Although administrative claims data are not perfect, it allows for studies on large populations in ''real-world'' settings; this study would have been prohibitively costly and time consuming using a chart review method. Lastly, unmea-

Table 3. Impact of Receipt of an ACEI/ARB on Total Healthcare Cost in the Following Year among Heart Failure Patients

	Healthcare Cost Coefficient Estimate (95% CI) ($n = 2,396$)
Received ACEI/ARB (reference: no)	0.06 (– 0.06–0.18)
Age (reference: <50 years)	
50–64 years	0.36 (0.14–0.57)**
≥ 65 years	0.66 (0.46–0.86)***
Female (reference: male)	– 0.001 (– 0.12–0.12)
≥ 10 drug types (reference: < 10 drug types)	0.66 (0.48–0.83)***
Seen by a cardiologist (reference: no)	0.01 (– 0.10–0.12)
Elixhauser comorbidity score	0.04 (0.01–0.08)*
Baseline healthcare cost	0.26 (0.21–0.32)***
Year (reference: 2005)	
2000	– 0.10 (– 0.26–0.05)
2001	– 0.09 (– 0.24–0.06)
2002	– 0.04 (– 0.19–0.11)
2003	– 0.02 (– 0.17–0.12)
2004	0.04 (– 0.11–0.18)

Note. ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker.
**p* value <.05,
***p* value <.01,
****p* value <.001.

sured factors such as stage of HF, left ventricular ejection fraction, body mass index, and smoking status that are unavailable in claims data, may have impacted healthcare utilization and healthcare cost. In particular, it is not possible to discriminate between systolic and diastolic HF using administrative claims data. If the distinction between these two types of HF was able to be made, there is the possibility of providing an ACEI/ARB to be cost saving.

In conclusion, this ''real-world'' study suggests that prescribing ACEIs/ARBs to patients with HF was effective in reducing hospitalizations and emergency department visits without a significant increase in total healthcare costs. Incentivizing the receipt of ACEIs/ARBs in these patients may be a suitable target for P4P programs, disease management programs, or newer complementary frameworks, such as value-based insurance design.

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References

Abarca, J., Malone, D. C., Armstrong, E. P., & Zachry, W. M. III. (2004). Angiotensin-converting enzyme inhibitor therapy in patients with heart failure enrolled in a managed care organization: Effect on costs and probability of hospitalization. *Pharmacotherapy, 24*, 351–357.

Ahmed, A., Centor, R. M., Weaver, M. T., & Perry, G. J. (2005). A propensity score analysis of the impact of angiotensin-converting enzyme inhibitors on long-term survival of older adults with heart failure and perceived contraindications. *American Heart Journal, 149*, 737–743.

Ahmed, A., Kiefe, C. I., Allman, R. M., Sims, R. V., & DeLong, J. F. (2002). Survival benefits of angiotensin-converting enzyme inhibitors in older heart failure patients with perceived contraindications. *Journal of the American Geriatric Society, 50*, 1659–1666.

Ahmed, A., Maisiak, R., Allman, R. M., DeLong, J. F., & Farmer, R. (2003). Heart failure mortality among older Medicare beneficiaries: Association with left ventricular function evaluation and angiotensin-converting enzyme inhibitor use. *Southern Medical Journal, 96*, 124–129.

Bart, B. A., Ertl, G., Held, P., Kuch, J., Maggioni, A. P., McMurray, J., et al. (1999). Contemporary management of patients with left ventricular systolic dysfunction. Results from the Study of Patients Intolerant of Converting Enzyme Inhibitors (SPICE) Registry. *European Heart Journal, 20*, 1182–1190.

Chung, R. S., Chernicoff, H. O., Nakao, K. A., Nickel, R. C., & Legorreta, A. P. (2003). A quality-driven physician compensation model: Four-year follow-up study. *Journal for Healthcare Quality, 25*, 31–37.

The CONSENSUS Trial Study Group. (1987). Effects of enalapril on mortality in severe congestive heart failure. Results of the Cooperative North Scandinavian Enalapril Survival Study (CONSENSUS). *New England Journal of Medicine, 316*, 1429–1435.

Eastman, R. C., Javitt, J. C., Herman, W. H., Dasbach, E. J., Copley-Merriman, C., Maier, W., et al. (1997). Model of complications of NIDDM. II. Analysis of the health benefits and cost-effectiveness of treating NIDDM with the goal of normoglycemia. *Diabetes Care, 20*, 735–744.

Echemann, M., Zannad, F., Briancon, S., Juilliere, Y., Mertes, P. M., Virion, J. M., & Villemot, J. P. (2000). Determinants of angiotensin-converting enzyme inhibitor prescription in severe heart failure with left ventricular systolic dysfunction: The EPICAL study. *American Heart Journal, 139*, 624–631.

Edep, M. E., Shah, N. B., Tateo, I. M., & Massie, B. M. (1997). Differences between primary care physicians and cardiologists in management of congestive heart failure: Relation to practice guidelines. *Journal of the American College of Cardiology, 30*, 518–526.

Elixhauser, A., Steiner, C., Harris, D. R., & Coffey, R. M. (1998). Comorbidity measures for use with administrative data. *Medical Care, 36*, 8–27.

Flather, M. D., Yusuf, S., Kober, L., Pfeffer, M., Hall, A., Murray, G., et al. (2000). Long-term ACE-inhibitor therapy in patients with heart failure or left-ventricular dysfunction: A systematic overview of data from individual patients. ACE-Inhibitor Myocardial Infarction Collaborative Group. *Lancet, 355*, 1575–1581.

Gotsman, I., Rubonivich, S., & Azaz-Livshits, T. (2008). Use of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in patients with congestive heart failure: An observational study of treatment rates and clinical outcome. *Israel Medical Association Journal, 10*, 214–218.

Granger, C. B., McMurray, J. J., Yusuf, S., Held, P., Michelson, E. L., Olofsson, B., et al. (2003). Effects of candesartan in patients with chronic heart failure and reduced left-ventricular systolic function intolerant to angiotensin-converting-enzyme inhibitors: The CHARM-alternative trial. *Lancet, 362*, 772–776.

Grigorian Shamagian, L., Roman, A. V., Ramos, P. M., Veloso, P. R., Bandin Dieguez, M. A., & Gonzalez-Juanatey, J. R. (2006). Angiotensin-converting enzyme inhibitors prescription is associated with longer survival among patients hospitalized for congestive heart failure who have preserved systolic function: A long-term follow-up study. *Journal of Cardiac Failure, 12*, 128–133.

Healthcare Cost and Utilization Project [HCUP]. (2008). Comorbidity Software, Version 3.3. Retrieved July 28, 2008, from www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp.

Hess, G., Preblick, R., Hill, J., Plauschinat, C. A., & Yaskin, J. (2009). Effects of angiotensin-converting enzyme inhibitor or angiotensin receptor blocker therapy after hospital discharge on subsequent rehospitalization for acute myocardial infarction and heart failure. *Congest Heart Fail, 15*, 170–175.

Institute of Medicine. (2009). *Initial national priorities for comparative effectiveness research.* Washington, DC: National Academy Press.

Jessup, M., Abraham, W. T., Casey, D. E., Feldman, A. M., Francis, G. S., Ganiats, T. G., et al. (2009). Focused update: ACCF/AHA guidelines for the diagnosis and management of heart failure in adults: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: Developed in collaboration with the International Society for Heart and Lung Transplantation. *Circulation, 119*, 1977–2016.

Johnson, D., Jin, Y., Quan, H., & Cujec, B. (2003). Beta-blockers and angiotensin-converting enzyme inhibitors/receptor blockers prescriptions after hospital discharge for heart failure are associated with decreased mortality in Alberta, Canada. *Journal of the American Collage of Cardiology, 42*, 1438–1445.

Jong, P., Demers, C., McKelvie, R. S., & Liu, P. P. (2002). Angiotensin receptor blockers in heart failure: Meta-analysis of randomized controlled trials. *Journal of the American Collage of Cardiology, 39*, 463–470.

Kermani, M., Dua, A., & Gradman, A. H. (2000). Underutilization and clinical benefits of angiotensin-converting enzyme inhibitors in patients with asymptomatic left ventricular dysfunction. *American Journal of Cardiology, 86*, 644–648.

Keyhan, G., Chen, S. F., & Pilote, L. (2007). Angiotensin-converting enzyme inhibitors and survival in women and men with heart failure. *European Journal of Heart Failure, 9*, 594–601.

Maciosek, M. V., Solberg, L. I., Coffield, A. B., Edwards, N. M., & Goodman, M. J. (2006). Colorectal cancer screening: Health impact and cost effectiveness. *American Journal of Preventive Medicine, 31*, 80–89.

McDermott, M. M., Feinglass, J., Lee, P., Mehta, S., Schmitt, B., Lefevre, F., et al. (1997). Heart failure between 1986 and 1994: Temporal trends in drug-prescribing practices, hospital readmissions, and survival at an academic medical center. *American Heart Journal, 134*(Pt. 1), 901–909.

Pedone, C., Pahor, M., Carosella, L., Bernabei, R., & Carbonin, P. (2004). Use of angiotensin-converting enzyme inhibitors in elderly people with heart failure: Prevalence and outcomes. *Journal of Gerontology Series A: Biological Sciences and Medical Sciences, 59*, 716–721.

Pfeffer, M. A., Braunwald, E., Moye, L. A., Basta, L., Brown, E. J. Jr, Cuddy, T. E., et al. (1992). Effect of captopril on mortality and morbidity in patients with left ventricular dysfunction after myocardial infarction. Results of the survival and ventricular enlargement trial. The SAVE Investigators. *New England Journal of Medicine, 327*, 669–677.

Pfeffer, M. A., McMurray, J. J., Velazquez, E. J., Rouleau, J. L., Kober, L., Maggioni, A. P., et al. (2003). Valsartan, captopril, or both in myocardial infarction complicated by heart failure, left ventricular dysfunction, or both. *New England Journal of Medicine, 349*, 1893–1906.

Pitt, B., Poole-Wilson, P. A., Segal, R., Martinez, F. A., Dickstein, K., Camm, A. J., et al. (2000). Effect of losartan compared with captopril on mortality in patients with symptomatic heart failure: Randomised trial—the Losartan Heart Failure Survival Study ELITE II. *Lancet, 355*, 1582–1587.

Ram, C. V. (2008). Angiotensin receptor blockers: Current status and future prospects. *American Journal of Medicine, 121*, 656–663.

Rector, T. S., Wickstrom, S. L., Shah, M., Thomas Greeenlee, N., Rheault, P., Rogowski, J., et al. (2004). Specificity and sensitivity of claims-based algorithms for identifying members of Medicare+Choice health plans that have chronic medical conditions. *Health Service Research, 39*(Pt. 1), 1839–1857.

Rochon, P. A., Sykora, K., Bronskill, S. E., Mamdani, M., Anderson, G. M., Gurwitz, J. H., et al. (2004). Use of angiotensin-converting enzyme inhibitor therapy and dose-related outcomes in older adults with new heart failure in the community. *Journal of General Internal Medicine, 19*, 676–683.

Smith, N. L., Psaty, B. M., Pitt, B., Garg, R., Gottdiener, J. S., & Heckbert, S. R. (1998). Temporal patterns in the medical treatment of congestive heart failure with angiotensin-converting enzyme inhibitors in older adults, 1989 through 1995. *Archives of Internal Medicine, 158*, 1074–1080.

The SOLVD Investigators. (1991). Effect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. *New England Journal of Medicine, 325*, 293–302.

The SOLVD investigators. (1992). Effect of enalapril on mortality and the development of heart failure in asymptomatic patients with reduced left ventricular ejection fractions. *New England Journal of Medicine, 327*, 685–691.

Stafford, R. S., & Radley, D. C. (2003). The underutilization of cardiac medications of proven benefit, 1990 to 2002. *Journal of the American College of Cardiology, 41*, 56–61.

Tribouilloy, C., Rusinaru, D., Leborgne, L., Peltier, M., Massy, Z., & Slama, M. (2008). Prognostic impact of angiotensin-converting enzyme inhibitor therapy in diastolic heart failure. *American Journal of Cardiology, 101*, 639–644.

Authors' Biographies

Judy Ying Chen, MD, MSHS, IMS Health, Woodland Hills, CA.

Ning Kang, MS, IMS Health, Woodland Hills, CA.

Deborah Taira Juarez, ScD, Hawaii Medical Services Association and Office of Public Health Studies, University of Hawaii at Manoa, Honolulu, HI.

Ronald S. Braithwaite, MD, MSC, FACP, School of Medicine, New York University, New York, NY.

Antonio Legorreta, MD, UCLA School of Public Health, University of California, Los Angeles, CA.

Krista A. Hodges, MPH, MBA, Hawaii Medical Services Association, Honolulu, HI.

Irina Yermilov, MD, MPHTM, IMS Health, Woodland Hills, CA.

Richard S. Chung, MD, Hawaii Medical Services Association, Honolulu, HI.

For more information on this article, contact Judy Ying Chen at judy.chen@us.imshealth.com.