Disparate Rates of Utilization and Progression to Combined Heart Failure and Chronic Obstructive Pulmonary Disease among Asians and Pacific Islanders in Hawai‘i

James Davis PhD; Elizabeth Tam MD; and Deborah Taira ScD

Abstract

The objectives of the study were to compare ethnic differences in the rates of emergency department (ED) visits and hospitalizations, and to examine ethnic differences in how quickly patients with either chronic obstructive pulmonary disease (COPD) or congestive heart failure (CHF) developed both diseases. A large health plan in Hawai‘i provided administrative data (2007 to 2010) on patients of Native Hawaiian, Japanese, Chinese, Filipino, and White race/ethnicity. The study found distinct patterns of health risks among the multi-ethnic population of patients with COPD, CHF, or both conditions. Native Hawaiians had the highest rates of ED visits and hospitalizations. Japanese, the largest ethnic group and relatively low health risks, were selected as the reference population. In adjusted regression models, Filipino patients with CHF developed COPD the most rapidly; 71% faster than Japanese patients. Compared to Japanese, Native Hawaiians with COPD transitioned to CHF 68% faster. The study highlights ethnic disparities in adverse events and disease progression in patients with COPD and CHF, with important implications for clinical practice. Health care providers may want to inform patients of ways to mitigate the risks.

Keywords

Ethnic groups, heart failure, chronic pulmonary disease, Hawai‘i, co-morbidity

Introduction

Overall, 15 million adults, or 6.3% of the US adult population, have been told by a health-care provider that they have Chronic Obstructive Pulmonary Disease (COPD).[1] COPD is a preventable and treatable disease characterized by airflow limitation that is not fully reversible, associated with difficulty breathing, cough, and other symptoms.[2] Another debilitating chronic disease, chronic heart failure (CHF), affects 5.1 million Americans and is characterized by an inability of the heart to pump sufficiently to maintain blood flow to meet body needs.[3]

Not only do these two conditions significantly impact morbidity and mortality, they contribute substantially to costs of care in the US health care system. Among dual eligible beneficiaries, defined as having both Medicare and Medicaid coverage, CHF and COPD accounted for the greatest portion of potentially preventable hospitalizations at 21.1% and 19.6%, respectively, as well as some of the highest 30-day readmission rates (23%-27%) of any type of patient.[4,5]

While CHF and COPD may exist separately, approximately 26%-33% of patients with CHF also are affected by COPD and this number is increasing.[5-7] Having multiple comorbidities is known to significantly impact health care utilization including hospitalizations, office visits, and medications.[7-10] The combination may be particularly challenging because COPD may complicate assessment of important signs and symptoms of CHF, such as fatigue or shortness of breath, and vice versa. In addition, as polypharmacy is common in patients with CHF and COPD, patients with both conditions are at increased risk for adverse drug events and reduced medication adherence, increasing the likelihood of a hospitalization or ED visit.[11]

COPD and CHF are both highly prevalent chronic diseases that share smoking as an etiologic factor, so it is expected that many patients will experience both conditions. Smoking as well as environmental pollutants that can lead to COPD are thought to create a low-grade, systemic inflammation.[12,13] Over time, the inflammation may accelerate atherosclerosis in patients with COPD, weaken the heart, and increase risks of left ventricular dysfunction and heart failure. A heightened arterial stiffness observed in patients with COPD is consistent with this hypothesis.[14]

The purpose of this study is to: (1) examine transition rates from having either CHF or COPD to both by race/ethnicity; (2) assess the impact of having CHF and/or COPD on health care utilization among a primarily Asian American and Pacific Islander population in Hawai‘i. Understanding ethnic differences may alert providers and patients to heightened risks of progression and of acute outcomes.

Methods

The study is a retrospective observational analysis of data obtained January 1, 2007-December 31, 2010 on members enrolled in a large health plan's care management programs for COPD or CHF. Patients were identified by the insurer's disease management algorithms. Diagnoses were confirmed whenever possible by contact of the members and their physicians. Exclusion of false positives required a physician's validation. We analyzed data from the start of the year following COPD or CHF identification until the end of the members' enrollment or 2010, whichever came first.

The study compared rates of hospitalizations, ED visits, and progression by ethnicity. Race/ethnicity, the predictor of primary interest, was based on self-report from member satisfaction surveys. Analyses are limited to the 76% of patients either self-identifying as part or full Native Hawaiian or who selected a single ethnicity from a list of the four other most common Hawai‘i ethnicities (Japanese, White, Filipino, and Chinese). Because Japanese were the largest ethnic subgroup and had favorable outcomes, Japanese served as the referent population for comparisons. Besides ethnicity, covariates in regression models included age, gender, island of residence (O‘ahu versus a Neighbor Island), years since diagnosis of

CHF or COPD, indicators of having diabetes, coronary artery disease, and chronic renal failure, and an indicator of high morbidity. High morbidity was defined as level 4 or 5 on the 5-point Johns Hopkins University's Adjusted Clinical Groups.[15] Morbidity levels were based on empirically derived weights determined by using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes.

Analyses used Cox proportional hazard models to examine progression from having only CHF or COPD to developing both diseases. Results are illustrated graphically using adjusted survival curves. In the proportional hazard models, chronic diseases and the index of high morbidity were modeled as time-dependent variables. A new line was created in the dataset for every change in a time-dependent variable, such as the onset of chronic kidney disease. The patient would be classified, for example, as not having chronic kidney disease on lines up to the onset, and as having chronic kidney disease on subsequent lines. In analyses in which emergency department (ED) visits and hospitalizations served as outcomes, negative binomial regression models were fit using generalized estimating equations with a compound symmetry correlation structure. The negative binomial model is appropriate where the outcomes are counts that occur more than rarely. These analyses were limited to patients with complete enrollment in a year and who, in addition, did not progress from COPD or CHF to having both conditions during the year. This approach excluded acute events related to new disease onset. In the dataset, patients had one line per year of inclusion. The regression model corrected for correlations between the repeated measurements from the same patients in different years. Results are presented as hazard ratios (HRs) or relative rates (RRs) with 95% confidence intervals (CIs). Analyses were performed using SAS version 9.3.

The University of Hawai'i institutional review board (IRB) granted the study an exemption from IRB review.

Results

Out of the plan's total enrollment of close to 700,000 members during this period, the analysis included 5,628 participants with COPD, CHF, or both and a total of 20,562 yearly observations from 2007 to 2010. Participants contributed from one to three years of observation. The study included Chinese, Filipinos, Whites, Native Hawaiians, and Japanese with prevalence ranging from 7% to 40%. Average ages by ethnicity ranged from 66 years for Native Hawaiian to 76 years for Japanese (Table 1). For all ethnicities, the majority resided on Oahu and had higher morbidity. At the start of follow-up, patients with CHF but not COPD were the most prevalent and patients with both diseases the least prevalent. Table 2 summarizes, by ethnicity, the number of patients with progression during follow-up and the mean numbers of ED visits and hospitalizations included in the analyses.

Transitions to COPD and CHF

During follow-up 114 patients with CHF (3.4%) developed COPD and 117 patients (5.9%) with COPD developed CHF. Figure 1 illustrates differences in the rates of progression using survival curves from adjusted proportional hazard models. Progression from having only COPD to having both CHF and COPD were greatest for Native Hawaiians (Figure1; Table 3). The hazard ratio relative to Japanese was 1.7 (95% CI=1.0, 3.0). Progression from having only CHF to also developing COPD was greatest for Filipinos. The HR relative to Japanese was 1.7 (95% CI=1.0, 2.8) (Table 3).

Table 1. Baseline characteristics of the study participants by ethnicity

Characteristic	Japanese	White	Native Hawaiian	Filipino	Chinese
Number of participants	2,274	1,039	1,084	834	397
Mean age ± SD	76.3 ± 12.7	71.0 ± 13.4	65.8 ± 13.6	68.5 ± 13.5	75.6 ± 12.8
Female	1090 (47.9%)	518 (49.9%)	583 (53.8%)	378 (45.3%)	170 (42.8%)
High morbidity	1731 (76.1%)	818 (78.7%)	743 (68.5%)	573 (68.7%)	312 (78.6%)
Residence on O'ahu	1752 (77.0%)	600 (57.7%)	707 (65.2%)	564 (67.6%)	369 (92.9%)
CHF & COPD					
COPD only	714 (31.4%)	437 (42.1%)	375 (34.6%)	366 (43.9%)	109 (27.5%)
CHD only	1451 (63.8%)	544 (52.4%)	632 (58.3%)	419 (50.2%)	277 (69.8%)
CHF & COPD	109 (4.8%)	58 (5.6%)	77 (7.1%)	49 (5.9%)	11 (2.8%)
Co-morbidities					
Diabetes	842 (37.0%)	256 (24.6%)	494 (45.6%)	336 (40.3%)	149 (37.5%)
Coronary artery disease	1141 (50.2%)	454 (43.7%)	497 (45.8%)	361 (43.3%)	216 (54.4%)
Chronic kidney disease	342 (15.0%)	92 (8.9%)	165 (15.2%)	153 (18.3%)	84 (21.2%)

Table 2. Percentage of patients with progression and mean numbers of emergency department visits and hospitalizations by ethnicity

Ethnicity	Number (%) with Progression		Mean Number of Events Per Year	
	CHF to COPD	COPD to CHF	Emergency Department Visits	Hospitaliza-tions
Japanese	46 (3.2)	37 (5.2)	1.6	2.0
White	18 (3.3)	30 (6.9)	1.8	1.9
Native Hawaiian	20 (3.2)	22 (5.9)	2.3	2.1
Filipino	24 (5.7)	23 (6.3)	2.1	1.8
Chinese	6 (2.2)	6 (5.5)	1.7	1.8

Abbreviations: CHF (heart failure);COPD (chronic obstructive pulmonary disease)

Table 3. Odds ratios for associations of patient characteristics with transitions from having only chronic heart failure or chronic obstructive pulmonary disease to developing both chronic conditions

Characteristics	Transition from CHF to CHF & COPD	Transition from COPD to CHF & COPD
Chinese	0.6 (0.3,1.4)	1.3 (0.5,3.1)
Filipino	1.7 (1.0,2.8)	1.5 (0.9,2.6)
Native Hawaiian	1.0 (0.6,1.7)	1.7 (1.0,3.0)
White	1.2 (0.7,2.1)	1.4 (0.8,2.3)
Age (years)	1.0 (1.0,1.0)	1.1 (1.0,1.1)
Female	1.0 (0.7,1.4)	0.9 (0.6,1.3)
High morbidity	1.4 (0.8,2.4)	1.7 (1.0,2.8)
O'ahu	1.1 (0.8,1.7)	0.7 (0.5,1.0)
Diabetes	1.2 (0.8,1.8)	1.4 (0.9,2.2)
CAD	2.0 (1.3,3.1)	2.2 (1.5,3.2)
CKD	2.1 (1.0,3.2)	1.4 (0.8,2.6)
Years post diagnosis	1.4 (1.2,1.5)	1.4 (1.3,1.6)

Abbreviations: CHF=chronic heart failure; COPD=chronic obstructive pulmonary disease; CAD=coronary artery disease; CKD=chronic kidney disease
For the ethnicities the reference is Japanese, for females the reference is male, for O'ahu the reference is neighboring islands, for high morbidity the reference is low morbidity, and for the chronic diseases the reference is not having the disease.

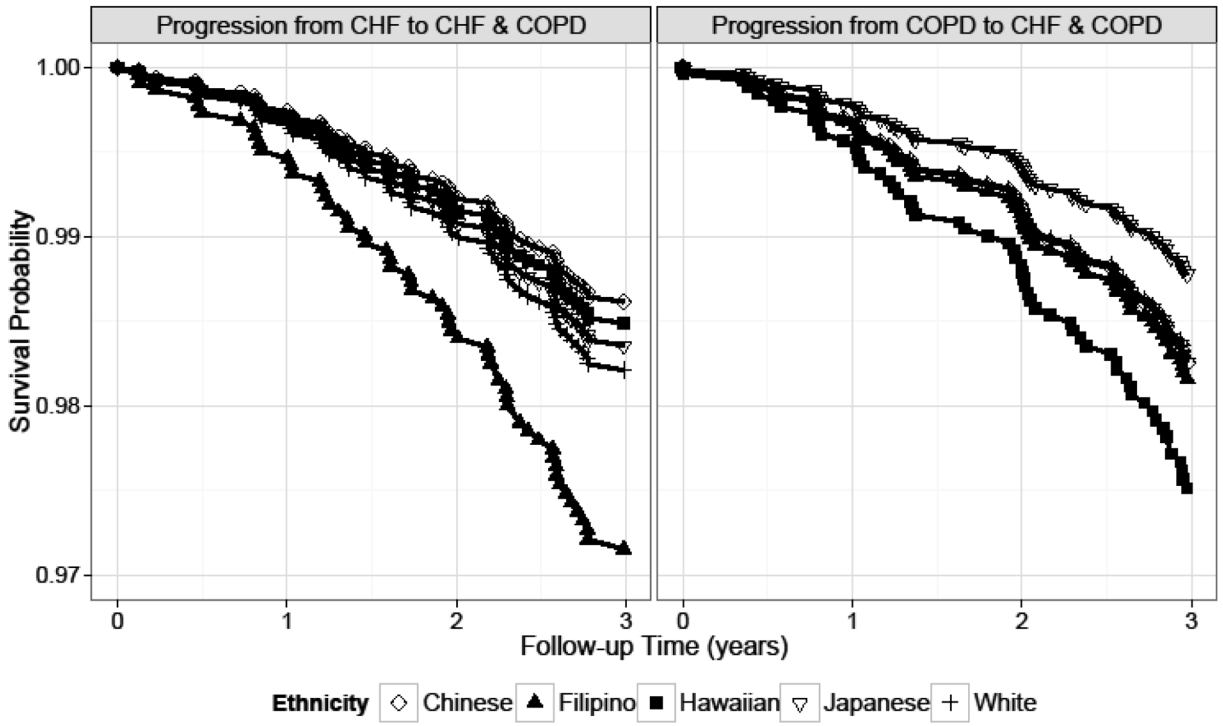

Figure 1. Adjusted survival curves illustrating the rates of transitions by ethnicity from having one of CHF or COPD to having both diseases

Curves were adjusted for age, gender, morbidity, years since diagnosis of CHF or COPD, residence on O'ahu or a neighbor island, diabetes, coronary artery disease, and chronic kidney disease.

ED visits and hospitalizations

The rates of ED visits were comparable for patients with only CHF or COPD, but increased for patients with both diseases (Table 4). Rates of hospitalization were a third higher for patients with CHF than for patients with COPD (RR=1.3, 95% CI=1.1, 1.6) and double for patients with both diseases compared to patients with only COPD (RR=2.2, 95% CI=1.7, 2.7). Among all participants 16.7% had one ED visit and 10.3% experienced two or more, whereas 11.7% incurred a single hospitalization and 7.1% had two or more.

The rates of acute events also differed by ethnicity and diseases (Table 5). Native Hawaiians with COPD had the highest rates of ED visits (RR=1.8, 95% CI=1.3, 2.5); ED rates for other ethnicities did not differ significantly from Japanese (Figure 2A). Japanese and Chinese with CHF had similar rates of ED visits; Filipinos, Native Hawaiians, and Whites had significantly higher rates (RR=1.4, 95% CI=1.2, 1.8; RR=1.5, 95% CI=1.2, 1.9; and RR=1.4, 95% CI=1.2, 1.8; Table 5). Rates of ED visits among patients with both CHF and COPD did not vary significantly by ethnicity. Hospitalizations showed less variability by race (Figure 2B). Native Hawaiians with COPD had the highest rates of hospitalizations (RR=1.4, 95% CI= 1.0, 2.0) compared to Japanese, although this difference was not significant (Table 5).

Table 4. Relative rates of emergency department visits and hospitalizations among patients with chronic obstructive pulmonary disease, heart failure, or both

Co-morbidities	ED Visits	Hospitalizations
COPD only	1.0	1.0
CHF only	1.1 (0.9, 1.3)	1.3 (1.1, 1.6)
COPD &CHF	1.7 (1.1, 2.6)	2.2 (1.7, 2.7)

Negative binomial regression models included age, gender, ethnicity, morbidity, O'ahu or other residence, diabetes, coronary artery disease, chronic kidney disease, ethnicity, and listed co-morbidities.
Abbreviations: CHF (heart failure); COPD (chronic obstructive pulmonary disease); SD (standard deviation), ED (emergency department)

Discussion

The study found racial/ethnic differences in the rates of progression to developing both conditions with heightened risks of ED visits and hospitalizations. Filipinos with CHF most rapidly developed COPD; Filipinos transitioned 70% faster than Japanese, the referent group. Other groups progressed at rates within 20% of the rate of Japanese. Although not significant, Native Hawaiians with COPD had the greatest estimated transition rate to CHF. We are not aware of other studies looking at racial/ethnic differences in progression from having either CHF or COPD to developing both.

Even after adjustment for demographic factors and comorbidities, Native Hawaiians with COPD but not CHF stood out with high rates of ED visits: 80% greater than the rates of Japanese. The rates of hospitalization among Native Hawaiians with COPD and CHF were 70% greater than Japanese. Filipinos, Native Hawaiians, and Whites with CHF, but not COPD, had significantly greater rates of ED visits compared to Japanese. Rates of hospitalizations among patients with CHF and without COPD did not differ appreciably by ethnicity. Native Hawaiians with CHF who also develop COPD appear the most vulnerable to hospitalizations.

Other studies have examined ethnic or racial rates of hospitalization for either CHF or COPD. Among patients with COPD in Kaiser Permanente, adjusted models found hospitalization rates compared to Whites to be 10% lower in African Americans, 40% lower in Hispanics,60% lower in all Asians and 70% lower in both Chinese and Japanese.[16] The rates of Filipinos were in between the rates of Asian ethnicities and Whites. Among Medicare beneficiaries in Maryland, African Americans with CHF had 62% higher adjusted rates of potentially avoidable

Table 5. Odds ratios for associations of patient characteristics with emergency department visits and hospitalizations

Characteristic	Emergency Department Visit			Hospitalization		
	COPD only	CHF only	Both	COPD only	CHF only	Both
Chinese	0.9(0.6,1.6)	0.9(0.7,1.3)	1.2(0.6,2.5)	1.4(0.7,2.8)	0.8(0.6,1.0)	1.0(0.5,2.2)
Filipino	1.2(0.9,1.6)	1.4(1.2,1.8)	0.7(0.4,1.4)	1.0(0.7,1.5)	1.0(0.8,1.2)	0.9(0.5,1.5)
Native Hawaiian	1.8(1.3,2.5)	1.5(1.2,1.9)	0.8(0.4,1.5)	1.4(1.0,2.0)	1.0(0.8,1.3)	1.7(1.0,2.8)
White	1.2(0.9,1.6)	1.4(1.2,1.8)	0.8(0.4,1.4)	1.2(0.8,1.6)	1.1(0.9,1.4)	1.0(0.6,1.6)
Age (years)	1.0(1.0,1.0)	1.0(1.0,1.0)	1.0(1.0,1.0)	1.1(1.0,1.1)	1.0(1.0,1.0)	1.0(1.0,1.0)
Female	1.1(0.9,1.4)	1.7(1.0,1.4)	0.6(0.4,1.1)	1.0(0.8,1.3)	1.0(0.9,1.2)	0.7(0.5,1.0)
O'ahu	1.1(0.8,1.4)	0.9(0.8,1.1)	1.1(0.7,1.7)	1.0(0.7,1.3)	1.0(0.9,1.2)	1.0(0.7,1.5)
High morbidity	2.6(2.0,3.4)	2.0(1.6,2.4)	2.6(1.3,4.9)	2.2(1.6,3.1)	2.1(1.6,2.6)	2.3(1.3,4.1)
Diabetes	1.2(1.0,1.6)	1.1(1.0,1.3)	0.9(0.5,1.4)	1.3(0.9,1.7)	1.2(1.1,1.5)	1.0(0.7,1.5)
CAD	1.4(1.1,1.7)	1.2(1.1,1.4)	1.0(0.5,1.9)	1.4(1.0,2.0)	1.2(1.0,1.5)	1.3(0.9,1.8)
CKD	1.0(0.7,1.5)	1.3(1.1,1.6)	1.1(0.7,1.7)	0.9(0.5,1.6)	1.5(1.3,1.8)	1.1(0.8,1.7)

Abbreviations: CHF=chronic heart failure; COPD=chronic obstructive pulmonary disease; CAD=coronary artery disease; CKD=chronic kidney disease
For the ethnicities the reference is Japanese, for females the reference is male, for O'ahu the reference is neighboring islands, for high morbidity the reference is low morbidity, and for the chronic diseases the reference is not having the disease.

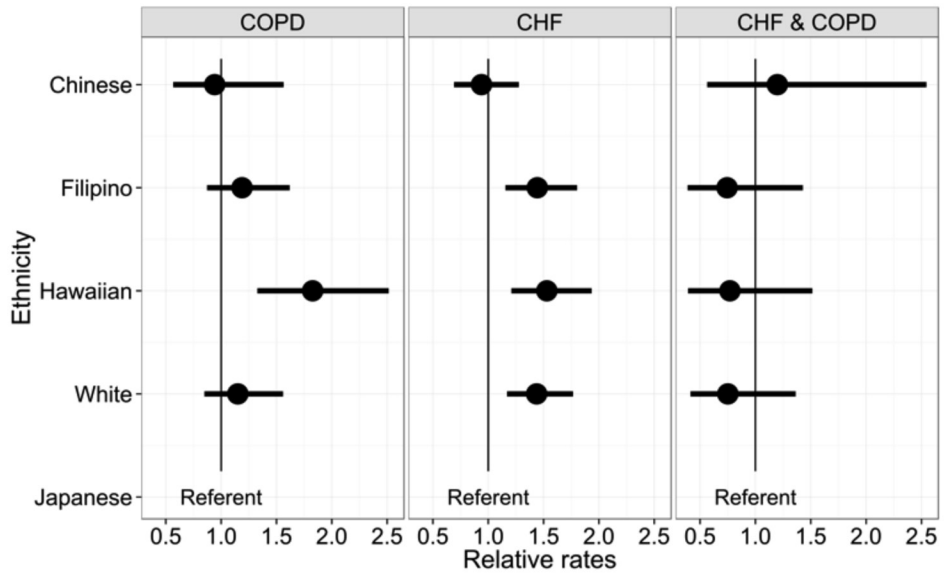

Figure 2A. Relative rates of emergency department visits stratified by ethnicity among patients with chronic obstructive pulmonary disease (COPD), heart failure (CHF) or both diseases

Negative binomial regression models included age, gender, morbidity, years since diagnosis of CHF or COPD, residence on O'ahu or a Neighbor Island, diabetes, coronary artery disease, chronic kidney disease, and ethnicity. Separate models were fit for patients with COPD only, CHF only, and CHF & COPD.

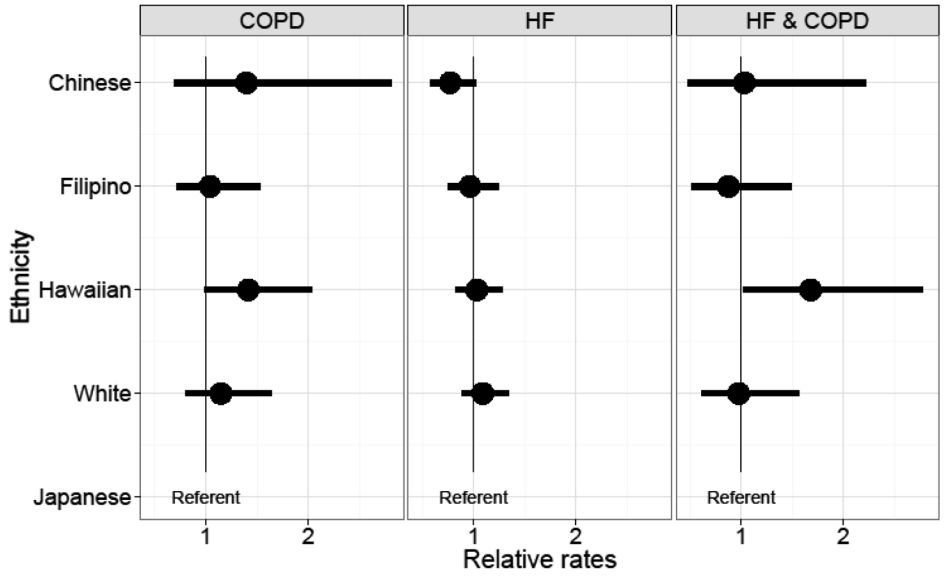

Figure 2B. Relative rates of hospitalizations stratified by ethnicity among patients with chronic obstructive pulmonary disease (COPD), heart failure (CHF) or both diseases

Negative binomial regression models included age, gender, ethnicity, morbidity, years since diagnosis of CHF or COPD, residence on O'ahu or a neighbor island, diabetes, and coronary artery disease, and chronic kidney disease.

hospitalizations then Whites.[17] By contrast, African Americans with COPD had 26% lower rates. An analysis of national data reported that the age- and sex-standardized rates of African American and Hispanics patients with COPD were within 10% of Whites.[18] Admission rates among the African American and Hispanic patients with CHF, by contrast, were 40% to 50% higher than White rates. A study of patients with CHF in the Military Health System's TRICARE program reported no significant racial/ethnic differences in potentially avoidable hospitalizations.[19] The study concluded that equal access to care might lessen racial/ethnic health disparities.

Earlier studies have reported increased risks of adverse events in patients with both COPD and CHF, as observed in our population.[12,14] An analysis of Medicare beneficiaries found patients with CHF had a 40% increased risk ambulatory care sensitive hospitalization when COPD was a comorbidity.[7] Age-adjusted results from the National Hospital Discharge Survey showed more than double the proportion of discharges when COPD was listed with CHF on discharge diagnoses.[20] Among Kaiser-Permanente patients with COPD, CHF as a comorbidity increased the age-adjusted rate of hospitalizations more than 5-fold.[21] Recent results from the Worchester Heart Failure Study examined community based hospitalizations for acute decompensated heart failure among a predominately White population.[22] A third of patients hospitalized with heart failure had a history of COPD. Patients with both conditions incurred a 10% higher risk of dying in the year after hospitalization, and a 40% higher risk at 5 years.

Our study has limitations to consider in interpreting the results. The study population derives from a single health plan in Hawai'i, and the results may not generalize to other populations. The health plan, however, is the major insurer in Hawai'i, covering close to half the state's total population of approximately 1.3 million people in 2007-2010. The insurer's disease algorithms are proprietary, a limitation in interpreting the results. Ethnicity is based on self-report and may have inaccuracies. Information on smoking, socioeconomic status, blood pressure, and body mass index is not available for this analysis. Aspects of health care such as frequency of utilization and being screened for the study conditions could also confound the results. The study results therefore are descriptive and limited by the data available from the health plan. The transitions investigated are fairly rare limiting the statistical power to assess ethnic disparities. The results, however, offer a starting point for more detailed studies.

The study offers evidence of ethnic disparities in two major chronic diseases, individually and in combination. In the coming decades Asians, Filipino, and Native Hawaiian populations, are projected to grow faster in numbers than Whites or African Americans.[23] Studies of the health and health care of Asians and Native Hawaiians have been limited by past studies that grouped them together in analyses, a practice that can obscure important disparities.

Our results show differences in the risks of adverse events among Asians, Filipinos, and Native Hawaiians with CHF, COPD, or both diseases. Filipinos transitioned the most rapidly from CHF to having CHF and COPD. Filipinos, particularly males, have a high smoking prevalence in Hawai'i[24], which may contribute to the rapid transition rates. Filipinos tend to have a poor medication adherence that may accelerate disease transitions.[25] Further, Filipinos have a high prevalence of hypertension and metabolic syndrome, important risk factors for major chronic diseases,[26,27] and relatively rapid rates of onset of hypertension and hyperlipidemia.[28] The study identifies possible disparities in adverse outcomes among Native Hawaiian patients with COPD. Native Hawaiians are one of the highest risk populations for cardiometabolic diseases in the United States.[29] In addition to Native Hawaiians, Whites and Filipinos with CHF were more likely than Japanese to have ED visits. Further study is needed to better understand what causes racial disparities in ED and hospitalization rates.

Conclusion

Our study findings contribute to the emerging literature on health and disparities among the multi-ethnic population of Hawai'i. The results highlight differences in rates of progression to having both diseases, differences that could lead to ethnic disparities in the prevalence of patients with COPD and CHF. Understanding the evolution of multiple from single chronic diseases in general could guide strategies to thwart the onset of the more complex and serious health conditions as well as the need to increase our knowledge of optimal co-management of these conditions. Our results showing increased rates for Filipinos and Native Hawaiians suggest that physicians and other health care providers may want to inform patients with one of the two conditions of their potential increased risk of developing the other and to emphasize ways in which they might mitigate these risks. Moreover, recognizing ethnic differences in risks of multi-morbidity can help the public health community target efforts for prevention.

Conflict of Interest

None of the authors identify any conflict of interest.

Acknowledgements

The research was supported by grant U54MD007584 from the National Institute on Minority Health and Health Disparities and grant 5 U54 GM104944 from the National Institute of General Medical Sciences. The content is solely the responsibility of the authors.

Authors' Affiliations:
- Office of Biostatistics & Quantitative Health Sciences, John A. Burns School of Medicine, University of Hawai'i, Honolulu, HI (JD)
- Department of Medicine, John A. Burns School of Medicine, University of Hawai'i, Honolulu, HI (ET)
- Daniel K. Inouye College of Pharmacy at University of Hawai'i at Hilo, Hilo, HI (DT)

Correspondence to:
James Davis PhD; John A. Burns School of Medicine, 651 Ilalo St., Biosciences Building 211C, Honolulu, HI 96813;
Email: jamesdav@hawaii.edu

References

1. Centers for Disease Control and Prevention. Chronic obstructive pulmonary disease among adults--United States, 2011. *MMWR Morb Mortal Wkly Rep.* 2012;61(46):938-943.
2. AmericanThoracicSociety. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med*. 1995;152:S77-S121.
3. Go AS, et al. Heart disease and stroke statistics--2013 update: a report from the American Heart Association. *Circulation*. 2013;127(1):e6-e245.
4. Segal M, et al. Medicare-Medicaid eligible beneficiaries and potentially avoidable hospitalizations. *Medicare Medicaid Res Rev.* 2014;**4**(1).
5. Havranek EP, et al. Spectrum of heart failure in older patients: results from the National Heart Failure project. *Am Heart J.* 2002;143(3): 412-417.
6. Wong CY, et al. Trends in comorbidity, disability, and polypharmacy in heart failure. *Am J Med.* 2011;124(2):136-143.
7. Braunstein JB, et al. Noncardiac comorbidity increases preventable hospitalizations and mortality among Medicare beneficiaries with chronic heart failure. *J Am Coll Cardiol*. 2003;42(7):1226-1233.
8. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009;360(14):1418-1428.
9. Anderson G, Horvath J. The growing burden of chronic disease in America. *Public Health Rep*. 2004;119(3):263-270.
10. Wolff JL, Starfield B, Anderson G. Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. *Arch Intern Med.* 2002;162(20):2269-2276.
11. Masoudi FA, Krumholz HM. Polypharmacy and comorbidity in heart failure. *BMJ*. 2003;327(7414):513-514.
12. Le Jemtel TH, Padeletti M, Jelic S. Diagnostic and therapeutic challenges in patients with coexistent chronic obstructive pulmonary disease and chronic heart failure. *J Am Coll Cardiol.* 2007;49(2):171-180.
13. Padeletti M, Jelic S, LeJemtel TH. Coexistent chronic obstructive pulmonary disease and heart failure in the elderly. *Int J Cardiol.* 2008;125(2):209-215.
14. Bhatt SP, Dransfield MT. Chronic obstructive pulmonary disease and cardiovascular disease. *Transl Res.* 2013;162(4):237-251.
15. Clark DO, et al. A chronic disease score with empirically derived weights. *Med Care*. 1995;33(8):783-795.
16. Tran HN, et al. Ethnicity and risk of hospitalization for asthma and chronic obstructive pulmonary disease. *Ann Epidemiol*. 2011;21(8):615-622.
17. O'Neil SS, et al. Racial disparities in hospitalizations for ambulatory care-sensitive conditions. *Am J Prev Med.* 2010;38(4):381-388.
18. Laditka JN, Laditka SB, Mastanduno MP. Hospital utilization for ambulatory care sensitive conditions: health outcome disparities associated with race and ethnicity. *Soc Sci Med.* 2003;57(8):1429-1441.
19. Bagchi AD, et al. Treatment and outcomes for congestive heart failure by race/ethnicity in TRICARE. *Med Care.* 2011;49(5):489-495.
20. Holguin F, et al. Comorbidity and mortality in COPD-related hospitalizations in the United States, 1979 to 2001. *Chest.* 2005;128(4):2005-2011.
21. Sidney S, et al. COPD and incident cardiovascular disease hospitalizations and mortality: Kaiser Permanente Medical Care Program. *Chest.* 2005;128(4):2068-2075.
22. Fisher KA, et al. Impact of COPD on the mortality and treatment of patients hospitalized with acute decompensated heart failure: the Worcester Heart Failure Study. *Chest.* 2015;147(3):637-645.
23. *National Healthcare Disparities Report, 2010*, A.f.H.R.a. Quality, Editor. 2010: Rockville, MD.
24. Look MA, T-BM, Agres R, Mau ML, Kaholokula JK. Assessment and Priorities for Health & Well-being in Native Hawaiians & other Pacific Peoples. 2013, Center for Native and Pacific Health Disparities research: Honolulu, HI.
25. Taira DA, et al. Antihypertensive adherence and drug class among Asian Pacific Americans. *Ethn Health.* 2007;12(3):265-281.
26. Grandinetti A, et al. Metabolic syndrome in a multiethnic population in rural Hawaii. *Ethn Dis.* 2005;15(2):233-237.
27. Ye J, et al. Cardiovascular risk factors among Asian Americans: results from a National Health Survey. *Ann Epidemiol*. 2009;19(10):718-723.
28. Davis J, Juarez D, Hodges K. Relationship of ethnicity and body mass index with the development of hypertension and hyperlipidemia. *Ethn Dis.* 2013;23(1):65-70.
29. Mau MK, et al. Cardiometabolic health disparities in native Hawaiians and other Pacific Islanders. *Epidemiol Rev.* 2009;31:113-129.