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Research Article

# Disparities of Heart Failure Hospital Outcomes in Hawaii, based on Race/ Ethnicity, Location and Primary Payer

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## ABSTRACT

We investigated disparities of Heart Failure (HF) hospitalization outcomes in Hawaii with respect to racial/ethnicity, primary payer, and county (island) in a population aged 65 and older, by focusing on four HF-related hospitalization outcomes: Cost billed per visit, length of stay, 30 days all-cause-readmissions, and in-hospital-mortality.Our findings suggest disparities among Native Hawaiians and Pacific Islanders on all four outcome types, compared to whites, including increased risk for mortality and readmissions. Also, disparities were observed among Filipinos and Japanese groups for at least one of the outcomes. Big island and Kauai counties were associated with shorter length of stays than Honolulu. Medicare patients had increased risks of readmissions and mortality compared to patients with private insurance.These findings may help the state government and health-care professionals gain a better understanding of potential barriers relating to the care of HF, which can further guide them in developing innovative strategies and adjusting the current health-care policies.

**Keywords:** Heart failure; Hospitalization; Hawaii; Ethnic disparity; 30-day readmission

## INTRODUCTION

Heart failure (HF) is one of the most common causes of hospitalization and a substantial financial burden of health care in the United States. Between 2013 and 2016, over 6.2 million American adults aged 20 years or above had HF, with over 800,000 new cases diagnosed annually [1-4].In Hawaii, heart disease is the leading cause of death and there about 8.4% age 65 and above population suffer from heart related conditions [5,6].

Health care disparities in HF related outcomes have been reported across a broad range of dimensions, and ethnicity is one of them [7-9].Hawaii's population is known to be one of the most diverse ethnic populations in the US and there exist significant racial/ethnic health disparities in this population [10]. In fact, literature suggests heart disease disproportionally affects Native Hawaiians and Pacific Islanders (NHPIs), making them a high-risk group [11,12]. The same populations were also found to be disproportionally affected by other chronic conditions including diabetes [13-16]. In addition, several other studies suggest that health disparities among Asian groups exist for different health conditions and healthcare utilization in Hawaii [13, 16-18].Previous studies found patterns of HF care and related outcomes are different between urban and rural areas [19,20].Hawaii is a cluster of islands. The island-based geographical complexity of the Hawaii state contributes further to the health disparities due to logistical reasons [18]. As counties in Hawaii signifies one or a few islands, disparities among islands could fairly reflect by the county disparities. The recent debate on healthcare reform has highlighted the influence of the primary payer type on patient care, which aimed at expanding healthcare to improve availability and delivery quality. Although these efforts have improved access for the low income and aging populations, significant gaps in access and quality still remain [21]. Literature suggests that disparities in quality and outcome in the US healthcare delivery system could be influenced by the source and type of payment [22,23]. In fact, HF-related in-hospital mortality rates, as well as lengths of stay, were found to be higher among Medicare populations compared to private insurance beneficiaries [24].

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There has been limited published literature regarding HF-associated hospitalizations among the elderly Hawaiian population in recent years. Due to the diverse ethnic distribution of the state, there could exist racial and ethnic disparities in HF hospital outcomes in Hawaii. Also, access to health care differs among the Hawaiian islands, but the magnitude of these differences and whether they affect HF-related hospitalization outcomes are unknown. In addition, further health service research efforts are needed to determine the effect of payer status in aspects of health-care utilization and outcomes. In this study, we used all-payer inpatient hospitalization data for the 2013–2017 period to investigate the effects of race/ethnicity, county, and primary payer on several key hospital outcomes: length of stay, total cost billed per visit, 30-day all-cause-readmission, and in-hospital mortality. We hypothesized that in Hawaii, there are significant race/ethnicity, county, and primary payer-based differences in HF hospital outcomes. Specifically, we expect NHPIs and/or Asian groups to be associated with increased readmission rates and in-hospital mortality rates compared to whites. Compared to Honolulu, we expected other counties in Hawaii to have reduced stays and costs. Furthermore, compared to private insurance, we expected Medicare beneficiaries to have increased length of stay and cost.

## METHODS

### Study data

In this retrospective study, we utilized Hawaii statewide inpatient data, from January 1, 2013, to December 31, 2017—a five-year period — to investigate relationships between patient characteristics such as race/ethnicity, county, primary payer, gender, and age, and a set of four utilization and outcome measures, e.g., length of stay, cost billed per visit, 30-day all-cause readmission, and in-hospital mortality for HF patients. Since HF is a condition that mainly occurs at the later stage of life, we focused on the elderly group (65 years and above), considering three age sub-groups: 65–74, 75–84, and 85 years or older.

The study was conducted on elderly patients who had one or more inpatient claims during the study period. Patients whose primary or secondary diagnosis at the time of hospitalization matched with International Classification of Diseases, 9th revision (ICD-9), code 428, or 10th revision (ICD-10), code I50, were included in the analysis. Both ICD-9: 428 and ICD-10: 428 diagnosis codes are commonly used for specifying HF [23-26]. The data analysis set included 19,973 patients with unique master patient identifiers (MPIs), which enable tracking multiple visits to different hospitals for a particular patient. The study did not involve non-Hawaiian residents or beneficiaries covered by the department of defense.

Demographic information included race/ethnicity, patient's location based on county, age-group, and gender. The race/ethnicity was self-identified, defined as white, Chinese, Japanese, Filipino, other Asian, NHPI, and others. The NHPI category also contained patients designated as part-Native-Hawaiians. The hospital location was identified by county, i.e., Hawaii (Big Island), Honolulu (O'ahu and the Northwestern Hawaiian Islands), Kauai (Kauai, Ni'ihau, Lehua, and Ka'ula), Maui (Maui, Kaho'olawe, Lāna'i, Molokai, and Molokini). Broadly, these counties reflect all major islands of the State. Among these counties, Honolulu is generally considered to be an urban area. Further, the primary payer type was categorized as Medicare, private insurance, and others, which also included Medicaid.

The proposed study focused on four outcomes: (1) length of stay per visit; (2) cost billed per visit; (3) all cause 30 days readmission; and (4) in-hospital mortality. The first three were assessed at each visit level. All visits eligible for all-cause 30-day readmission were dichotomized as Yes (1) and No (0). To evaluate the in-hospital mortality, we focused on each patient's last visit during the five years study period. In-hospital mortality was dichotomized as Dead (1) and Not-dead (0) at the end of the last hospital admission for each patient. All analyses accounted for the effects of race/ethnicity, primary payer, county, age, and gender. The University of Hawaii Institutional Review Board (CHS #23362) approved this study.

### Statistical analysis

The unique patient information was summarized by descriptive statistics as percentages for race/ethnicity, county, primary payer, age, and gender categories. The main analysis was conducted for each of the four outcomes (length of stay, cost billed per visit, all cause 30 days readmission, and in-hospital mortality). Generalized mixed effect models were used to evaluate the effects of race/ethnicity, county/island, and payer type, while controlling for age and gender, and to account for multiple visits. These models contained subject-specific intercepts as random components. Length of stay and cost per visit were transformed using the log transformation prior to developing regression models. A Logit link was used for the binary outcome. False Discovery Rate (FDR) was utilized for correcting the potential error due to the multiplicity of tests. All analyses were conducted using R software version 3.2.0.

## RESULTS

The demographic details were summarized for the first visit of each patient (Table 1). Approximately equal proportions of patients were reported for each age subcategory, with 32.5%, 32.9%, and 32.6% for 64–74, 75–84, and 85 years and above, respectively. There were 23.0% whites, 17.9% NHPIs, 6.9% Chinese, 17.2% Filipinos, 25.5% Japanese, and 2.4% other Asians. Most of these patients were admitted to hospitals in the Honolulu county (71.7%). For 93.4% of the patients, the primary payer type was Medicare, while for 6% of them it was private insurance. Male patients comprised 51.3% of the study population. Supplementary Table 1 summarizes demographic details with respect to each ethnic group.

**Table 1:** Sample demographics for 2013-2017. NHPI: Native Hawaiian and Pacific Islanders.

| Variable | Count (%) |
|---|---|
| Unique Patient Count | 19,973 |
| Race/Ethnicity | |

| | |
|---|---|
| Whites | 4,598 (23.02%) |
| NHPI | 3,578 (17.91%) |
| Chinese | 1,394 (6.98%) |
| Filipinos | 3,434 (17.19%) |
| Japanese | 5,101 (25.54%) |
| Other Asians | 480 (2.40%) |
| Others | 1,388 (6.95%) |
| County in Hawaii | |
| Honolulu (Oahu) | 14,318 (71.69%) |
| Hawaii (Big-Island) | 3,051 (15.28%) |
| Kauai | 927 (4.64%) |
| Maui | 1,677 (8.40%) |
| Primary Insurance Type | |
| Medicare | 18,652 (93.38%) |
| Private Insurance | 1,199 (6.00%) |
| Other (including Medicaid) | 122 (0.61%) |
| Age Category (years) | |
| 64 Age 74 | 6,493 (32.51%) |
| 75 Age 84 | 6,573 (32.91%) |
| 85 and above | 6,907 (34.58%) |
| Gender | |
| Male | 10,241 (51.27%) |
| Female | 9,732 (48.72%) |
| Total Inpatient Visits | 39,558 |
| Average Cost Billed Per Visit (95% CI) | $52,965 ($52,225, $53,704) |
| Average Length of Stay (95% CI) | 7.37 days (7.26, 7.48) |
| Total In-Hospital Deaths | 3,107 |
| Total Readmissions | 3,952 (out of 28,637 eligible cases) |

## Length of Stay

The overall average length of stay per visit was estimated to be 6.90 days with 95% Confidence Interval (CI) [6.82, 6.92]. In terms of ethnicity, the average length of stay were shorter for NHPI (4.2% less, 95% CI=0.8%, 7.5%), Filipinos (6.2% less, 95% CI=2.8%, 9.5%), Other-Asians (7.6% less, 95% CI=0.4%, 14.3%), and other ethnic group (4.9% less, 95% CI=0.6%, 9.2%) patients compared to whites, controlling all other factors. The average length of inpatient visits reported was also less in rural counties such as Hawaii (9.8% less, 95% CI=6.8%, 12.7%) and Kauai (11.3% less, 95% CI=6.3%, 16.1%) compared to the urban county Honolulu. Older patients had shorter average length of stay compared to the age 64-74 year group, with the bigger decrease observed for the 85 year and above group (75-84 year: 4.0% less, 95% CI=1.4%, 6.6%; 85+ years: 12.5% less, 95% CI=9.9%, 15.0%). There was no gender difference observed for this outcome. Individuals with private insurance coverage were found to be associated with 6.4% (95% CI=2.5%, 11.0%) shorter length of stay compared to the Medicare group. Additional results and illustrations are given in the supplementary material, including the marginally estimated expected length of stay correspond to each ethnic group (Supplementary Table 2) and graphical illustrations of the conditionally estimated length of stays correspond to a few selected patient profiles (Supplementary Figures 1 and Figure 2).

**Table 2:** Effects of race/ethnicity, county in Hawaii, age category, and gender on length of stay and total cost billed outcomes. The results were based on generalized linear mixed effect models. For an estimated group regression coefficient (b), the relative reduction compared to the reference group, is given by [1-exp(b)]%. Ref: Reference Group. C.I: Confidence Interval. NHPI: Native Hawaiian and Pacific Islander. The FDR adjusted p-values found to be significant at 5% level are indicated in an asterisk sign (*).

| Variable | Category | Length of Stay | | Total Cost Billed Per Visit | |
|---|---|---|---|---|---|
| | | Regression Coefficient (95% C.I.) | p-value | Regression Coefficient (95% C.I.) | p-value |
| | (Intercept) | 1.877 (1.843, 1.911) | <0.001 | 10.747 (10.707,10.786) | <0.001 |
| Ethnicity (Ref: White) | NHPI | -0.043 (-0.078, -0.008) | 0.017* | -0.133 (-0.169, -0.098) | <0.001* |

| | | | | | |
|---|---|---|---|---|---|
| | Chinese | 0.002 (-0.048, 0.052) | 0.938 | -0.027 (-0.078, 0.024) | 0.303 |
| | Filipino | -0.064 (-0.100, -0.028) | 0.001* | -0.046 (-0.076, -0.015) | 0.004* |
| | Japanese | 0.008 (-0.026, 0.042) | 0.650 | 0.018 (-0.017,0.052) | 0.319 |
| | Other Asian | -0.079 (-0.154, -0.004) | 0.042 | -0.058 (-0.135, -0.019) | 0.145 |
| | Others | -0.050 (-0.096, -0.006) | 0.030 | -0.109 (-0.155, -0.063) | <0.001* |
| County (Ref: Honolulu) | Hawaii (Big-island) | -0.103 (-0.136, -0.070) | <0.001* | -0.252 (-0.286, -0.218) | <0.001* |
| | Kauai | -0.120 (-0.176, -0.065) | <0.001* | -0.023 (-0.080, 0.034) | 0.429 |
| | Maui | -0.007 (-0.035, 0.050) | 0.734 | -0.067 (-0.110, -0.024) | 0.003* |
| Insurance type (Ref: Medicare) | Private | -0.071 (-0.117, -0.025) | 0.003* | -0.064 (-0.112, -0.017) | 0.008* |
| | Other | 0.142 (0.007, 0.277) | 0.042 | 0.211 (0.074,0.347) | 0.003* |
| Gender (Ref: Female) | Male | 0.014 (-0.010, 0.034) | 0.250 | 0.067 (0.043,0.091) | <0.001* |
| Age (Ref: 65-74 yrs.) | 75-84 yrs. | -0.041 (-0.068, -0.014) | 0.004* | -0.089 (-0.113, -0.066) | <0.001* |
| | 85+ yrs. | -0.133 (-0.162, -0.104) | <0.001* | -0.285 (-0.310, -0.260) | <0.001* |
| Year (Ref: 2013) | 2014 | - | - | 0.062 (0.034, 0.090) | <0.001* |
| | 2015 | - | - | 0.086 (0.056, 0.116) | <0.001* |
| | 2016 | - | - | 0.171 (0.142, 0.199) | <0.001* |
| | 2017 | - | - | 0.244 (0.213, 0.274) | <0.001* |

## Cost billed per visit

Models for total cost billed included year effects as such effects that can be generally anticipated for financial outcomes. Clearly, those effects were observed to be significant and contained upward trends from 2013 to 2017. Correspondingly, the estimated average cost per visit in 2013 was about $47,928 (95% CI=46,322, 49,534), which increased by 25% to $59,871 in 2017 (95% CI=$57,866, $61,877). Compared to whites, NHPI (12.4% less, 95% CI=9.3%, 15.5%), Filipino (4.5% less, 95% CI=1.5%, 7.3%), other Asians (5.6% less, 95% CI=1.9%, 12.6%), and other ethnic groups (10.3% less, 95% CI=6.1%, 14.4%) had lower costs, adjusting for all other factors.Compared to Honolulu, costs were significantly lowered in Hawaii (22.3% less, 95% CI=19.6%, 24.9%) and Maui (6.4% less, 95% CI=2.4%, 10.4%). The average cost involved with treating older patients were significantly reduced (75-84 years: 8.5% less, 95% CI=6.4%, 10.7%; 85+ years: 24.8% less, 95% CI=22.9%, 26.7%) compared to the age 64-74 group. Males had increased cost (6.9% more, 95% CI=4.4%, 9.5%) than females. Compared to Medicare, a significant 6.2% (95% CI=1.7%, 10.6%) cost reduction was observed for patients with private insurance. Additional results and illustrations for the cost billed per visit values are provided in the supplementary material (i.e., Supplementary Table 2, Figures 3 and Figure 4).

**Table 3:** Effects of race/ethnicity, county in Hawaii, age category, and gender on odds of observing In-hospital Mortality and Readmission. The results were based on generalized linear model and generalized mixed effect model. Ref: Reference group. CI: Confidence Interval. NHPI: Native Hawaiian and Pacific Islander. The FDR adjusted p-values found to be significant at 5% level are indicated in an asterisk sign (*).

| Factor Type | Factor | Readmission | | In-hospital Mortality | |
|---|---|---|---|---|---|
| | | Odds Ratio (95% CI) | p-value | Odds Ratio (95% CI) | p-value |
| | (Intercept) | 0.147 (0.132, 0.164) | <0.001 | 0.136 (0.120, 0.154) | <0.001 |
| Ethnicity (Ref: White) | NHPI | 1.212 (1.087, 1.352) | 0.001* | 1.154 (1.015, 1.311) | 0.029 |
| | Chinese | 1.069 (0.910, 1.256) | 0.417 | 1.138 (0.959, 1.352) | 0.139 |
| | Filipino | 1.059 (0.944, 1.189) | 0.327 | 1.283 (1.131, 1.454) | <0.001* |
| | Japanese | 1.078 (0.967, 1.201) | 0.176 | 1.244 (1.107, 1.398) | <0.001* |
| | Other Asian | 0.903 (0.700, 1.164) | 0.430 | 1.157 (0.890, 1.505) | 0.276 |
| | Others | 1.199 (1.039, 1.383) | 0.013* | 1.190 (1.003, 1.413) | 0.046 |
| County (Ref: Honolulu) | Hawaii (Big-island) | 0.964 (0.872, 1.064) | 0.464 | 0.757 (0.672, 0.853) | <0.001 |
| | Kauai | 1.094 (0.925, 1.294) | 0.294 | 0.896 (0.741, 1.084) | 0.257 |
| | Maui | 0.864 (0.753, 0.993) | 0.039 | 0.897 (0.775, 1.308) | 0.145 |
| Insurance type (Ref: Medicare) | Private | 0.829 (0.703, 0.977) | 0.025* | 0.793 (0.655, 0.961) | 0.018* |
| | Other | 0.848 (0.489, 1.471) | 0.557 | 1.185 (0.701, 2.002) | 0.526 |
| Gender (Ref: Female) | Male | 1.034 (0.963, 1.110) | 0.356 | 1.137 (1.051, 1.230) | 0.001* |
| Age (Ref: 65-74 yrs.) | 75-84 yrs. | 0.994 (0.912, 1.084) | 0.897 | 1.172 (1.059, 1.296) | 0.002* |
| | 85+ yrs. | 0.965 (0.879, 1.059) | 0.455 | 1.180 (1.064, 1.308) | 0.002* |

## 30-day readmission

The overall chances of readmission were 13.6% with 95% CI [13.2%, 14.0%]. NHPI (OR=1.212, 95% CI=0.132, 0.164) and other (OR=1.199, CI=1.039, 1.383) patients had significantly increased odds for readmission, compared to whites. Maui (OR=0.864, 95% CI=0.753, 0.993) county was associated with a less risk of readmission as compared to Honolulu. Moreover, there were no effects observed on readmission with respect to gender or age. Private insurance was associated with reduced odds (OR=0.829, 95% CI=0.703, 0.977) on the 30-day all-cause readmission, compared to Medicare patients (Table 3).

## In-hospital mortality

The overall chance for in-hospital death was found to be 15.1% with 95% CI [14.6%, 15.6%]. Significant ethnic differences were observed for this outcome. NHPI (OR=1.154, 95% CI=1.015,

1.311), Filipinos (OR=1.283, 95% CI=1.131, 1.454), Japanese (OR=1.244, 95% CI=1.107, 1.398), and other ethnic groups (OR=1.190, 95% CI=1.003, 1.413) had increased odds of in-hospital mortality, compared to whites. In terms of county, patients from Hawaii county had reduced odds (OR=0.757, 95% CI=0.672, 0.852) on this outcome, compared to Honolulu. Also, males had a higher risk than females (OR=1.137, 95% CI=1.051, 1.230). As expected, higher age was associated with increased risks in both age groups (75–84 years: OR=1.172, 95% CI=1.059, 1.296; 85+ years: OR=1.180, 95% CI=1.064, 1.308). In comparison with the Medicare patients, patients with private insurance showed significantly lower odds of in-hospital mortality (OR=0.793, 95% CI=0.665, 0.961).

## DISCUSSION

In this study, we investigated the disparities among Hawaiian counties, racial/ethnic groups, and primary payers for four HF inpatient hospital outcomes: Length of stay, cost billed per visit, 30 days all-cause readmissions, and in-hospital mortality. The study population was aged 65 years and above, as this group experiences the greatest risk of HF condition [27]. We utilized Hawaii statewide inpatient data for the five years period of 2013 to 2017 for the analysis. Due to the diverse ethnic distribution and the island-based complex geographical distribution of the state of Hawaii, we anticipated racial/ethnic and location-based disparities for the above outcomes. Moreover, we were interested in assessing the potential effects of the primary payer on the aforementioned hospital outcomes, as such associations have been suggested in the literature [22,23]. All the analyses performed were adjusted for age and gender effects.

In alignment with our expectations, the study revealed significant racial disparities on multiple outcomes related to HF hospitalizations. As we hypothesized, the NHPI population had an increased risk of in-hospital mortality and readmissions, compared to whites. This population is known to have poor health outcomes, including cardiovascular conditions, chronic kidney disease, and diabetes [14,15]. Poor dietary choices, lack of physical activity, tobacco and alcohol use, and high rate of obesity among NHPIs are several factors that place them at an increased risk for poor health and health outcomes [15]. The observed differences in these HF outcomes also highlight the need for the identification, the development and implementation of best clinical practices for ethnic minority groups such as NHPI [28, 29]. Often, these groups are under-represented in clinical research studies such as clinical trials, resulting in inadequate power for conducting subgroup analysis with a focus on these groups. Furthermore, we noted that the length of inpatient hospitalizations and cost were lower for NHPIs as compared to whites. This observation remained consistent when we performed a sensitivity analysis by excluding all death cases, possibly suggesting that NHPIs might have been discharged earlier than they were supposed to be. Possible reasons for this disparity could be economic and health literacy inequality between the two groups. Notably, previous studies suggest that NHPIs in Hawaii suffer from high poverty rates and poor health literacy rates [30, 31]. The combination of these two factors could influence their health-care utilization. For instance, shortening the length of stay could lead to less consumption of facilities, drugs, procedures, and less engagement as well as faster return of the patient to the workplace [32].

The Filipino and Japanese ethnic groups showed a substantially higher risk of in-hospital mortality, compared to whites. The literature posits that American Filipinos are a high-risk group for cardiovascular disease [33-35]. For example, in-hospital mortality due to ischemic stroke was found to be higher for Hawaiian-Filipinos compared to whites [33]. American Filipinos also have a higher risk of other major chronic conditions such as diabetes [36]. Previous studies also found an increased risk for cardiovascular disease and mortality in the American-Japanese population [37,38]. Overall, there were no significant differences observed for the Chinese population compared to whites for any outcomes studied; however, a few previous studies suggest increased mortality rates for the American-Chinese group, compared to whites, for cardiovascular conditions such as hemorrhagic stroke in other areas of the US [39]. We should point out that the Chinese population included in this study was proportionately small, which could have affected the statistical power.

We observed a clear payer effect on all four outcomes. As hypothesized, Medicare patients had poor outcomes compared to patients with private insurance in terms of 30-day readmissions and in-hospital mortality. Medicare patients' visits associated with increased costs and longer stays, compared with private insurance patients. Similarly, increased mortality and longer length of stay for Medicare HF patients were suggested in the literature [24]. Medicare patients are known to be associated with poor outcomes for a wide range of major surgery types [40].

Both the length of stay and the cost billed per visit are two measures that correlated positively. In fact, we observed a spearman's correlation coefficient of 0.72 between them. Our findings showed general trends that agree with these associations. For patients with older ages, as expected, a higher in-hospital mortality rate was observed. However, age did not seem to influence readmission rates. Both the length of stay and cost billed per visit were observed to decrease with age. In general, older patients are considered to have more complicated cases due to the increased prevalence of chronic conditions and disability rates at an older age [41,42]. Although we expected a longer length of stay as well as increased cost for older patients, the results contradicted this assumption. We observed the same patterns in a sensitivity analysis conducted by excluding all death cases and readmissions. Interestingly, similar observations were reported in the literature. For example, an overall summary of Healthcare Cost and Utilization Project Statistical showed reduced average inpatient length of stay for age 85 and above cases, compared to the age 65-84 group [43]. Another study conducted on idiopathic pulmonary fibrosis also showed a significant reduction in both length of stay and cost with age [44]. Thus, future studies must focus on explaining this association.

The gender factor was found to be associated with the cost billed per visit and in-hospital mortality, with males having high rates for both outcomes as compared to females. Literature suggests increased costs of care for heart failure in males, compared to

females [45]. Also, a similar pattern was found in a few other disease populations by other studies. For example, increased inpatient costs was reported for males, among patients with psychiatric diagnoses [46]. A study conducted on overall health-care costs using data from Health Care Cost Institute and the Medicare showed substantially increased costs for males at the elderly age [47]. The gender effect on HF in-hospital mortality is unclear based on the current literature with the majority reported no effect [48-51].

Broadly, counties in Hawaii comprise a set of islands. Our analysis showed some county-specific impact on HF hospitalization. We observed significantly reduced length of stay in Big Island and Kauai, compared to Honolulu. These effects remained unchanged when we performed a sensitivity analysis, excluding in-hospital death cases. The shorter length of stay on Big Island and Kauai could be attributed to the fact that more complex cases are transported to Honolulu, which could also be the reason for the significantly reduced inpatient mortality risk observed in Big Island and the reduced readmission rates in Maui, compared to Honolulu. Further, shortage of both local primary care and specialist physicians, as well as other barriers in access to care may have also contributed to the variations in health-care utilization among these islands [52-54]. Previous studies have suggested an association between hospital size and HF-related outcomes. For instance, high-capacity hospitals were reported to provide a higher quality of care and better outcomes for their patients but at an increased expense [34]. In Hawaii, this is confounded by the fact that the number of high-capacity hospitals is higher in urban areas such as Honolulu.

A primary admission for HF is an indicator of negative health outcomes. The average length of stay for HF patients has remained stable between 5-6 days in most parts of the country. However, with the increasing pressure on hospitals to reduce the length of stay, this number is likely to decrease in the coming decades. Also, the overall length of stay could be deceptive if a patient dies during the hospitalization.

In the US, among Medicare HF patients, the risk of re-hospitalization within 30 days is 21.9% and 1 year mortality is 35.8% [55], and yet, the daily readmission risk does not decrease by half until nearly 40 days following an index hospitalization [56]. Sud et al. conclude that there is a higher rate of readmission for a length of stay shorter than 5 days or longer than 6 days, which is quite significant given that physicians and health systems experience financial pressures and incentives to not only decrease the length of stay but also prevent 30 days readmission [57].

The cost of hospitalization for patients with HF is substantial. This includes the initial cost of hospitalization and that of subsequent readmissions. Given that patients with HF are likely to have multiple other comorbid conditions, the risk of hospitalization will always remain high; however, certain interventions can be implemented to reduce the number of hospitalizations, such as the optimization of evidence-based medical therapies, utilization of tele-health approach especially for neighboring islands, improvement of transitions of care,frequent outpatient follow-ups, employment of home health services, and targeting specific socio-economic factors associated with higher risk of hospitalization.

Although this study intended to explore HF-related disparities in Hawaii, our findings could be useful and significant for other multicultural locations in the US. For instance, findings concerning the Filipino population could be useful for other states, as Filipino is now the second-largest Asian population in the US [58]. While many published studies are limited to the public payer population, our findings are not limited. However, it should also be noted that more than 90% of the current population studied was covered by public insurances. Moreover, to improve the quality of care, unaccounted factors that could potentially influence the performance should also be investigated. Although we explored disparities in four HF hospital outcomes among Hawaiian islands, this study may provide insights into an urban and rural comparison. In the current health-care setting, gathering patients' information related to their social determinants may still not be as focused as it should be. However, the development of evidence-based strategies that account for such information could be useful in improving both patient care and health-care resource management. For example, our study showed increased readmission rates and mortality for the NHPI population. Health-care providers and administrators should consider such racial differences when developing early prevention strategies for subgroups of patients with higher risks. Further modification of these strategies requires accurate assessments of patient adherence and targeted outcomes.

Similar to other studies based upon administrative data, erroneous data entries may have influenced analyses and the subsequent conclusions. In fact, self-reported demographic details may not reflect the complete profile of some of the subjects. We utilized both ICD9 and 10 codes to identify HF conditions. There is a great concordance between ICD9 and 10 coding strategies, although minor discrepancies can be still expected [59].In the current analysis, we used the inpatient mortality indicator corresponding to the last visit within the study period, which could lead to overestimation of the overall mortality rate. However, it is reasonable to assume that this approach does not substantially impact the comparison of risks among different groups as risk comparison was based on a relative measure. It is important to note that, we performed the mortality analysis while accounting for the re-admission factor as a sensitivity analysis. However, the results remained unchanged, showing no effect by the re-admission. The study did not account for the patient's burden of the chronic conditions, as such information were not available in the data for assessment. Also, we did not focus on tracking patients who transferred hospitals between different counties, including from other counties to Honolulu. Despite these limitations, our study provides useful insights into racial/ethnic, county/island, and payer disparities in the use of inpatient care for HF in Hawaii.

## CONCLUSION

Our findings suggest that there are increased readmissions and in-hospital mortality rates for the NHPI group, compared to whites. In addition, increased in-hospital mortality rates were found for Filipinos and Japanese groups. Medicare beneficiaries were associated with increased cost, length of stay, readmission rates, and in-hospital mortality, compared to individuals with

private insurance coverage. The county-wise effects that were observed suggested disparities among the Hawaiian islands, in terms of HF treatments. These findings may help the state government and health-care professionals gain a better understanding of potential barriers relating to the care of HF, which can further guide them in developing innovative strategies and adjusting the current health-care policies so that they better address the needs of ethnic minority populations and medically underserved areas.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

## REFERENCES

1. Benjamin EJ, Muntner P, Alonso A, Bittencourt MS, Callaway CW. Heart disease and stroke statistics-2019 Update: A Report From the American Heart Association.Circulation. 2019; 139(10):e56-e528.
2. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD. Executive summary: Heart disease and stroke statistics-2012 update: A report from the American Heart Association. Circulation. 2012; 125(1):188-97.
3. Heidenreich PA, Albert NM, Allen LA. Forecasting the impact of heart failure in the United States: A policy statement from the American Heart Association. Circ Heart Fail. 2013; 6(3):606–619.
4. Kilgore M, Patel HK, Kielhorn A, Maya JF, Sharma P. Economic burden of hospitalizations of medicare beneficiaries with heart failure. Risk ManagHealthc Policy. 2017;10:63–70. Published 2017 May 10.
5. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: Final data for 2017. National Vital Statistics Reports; vol 67 no 8. Hyattsville, MD: National Center for Health Statistics. 2018.
6. America's Health Rankings analysis of CDC, Behavioral Risk Factor Surveillance System, United Health Foundation, AmericasHealthRankings.org. 2020
7. U.S. Census Bureau, author. 2010 Census of Population and Housing, Summary Population and Housing Characteristics, CPH-1-1. Washington, DC: United States U.S. Government Printing Office; 2013.
8. Dupre ME, Gu D, Xu H, Willis J, Curtis LH, Peterson ED. Racial and Ethnic Differences in Trajectories of Hospitalization in US Men and Women With Heart Failure. J Am Heart Assoc. 2017;6(11):e006290.
9. Durstenfeld MS, Ogedegbe O, Katz SD, Park H, Blecker S. Racial and Ethnic Differences in Heart Failure Readmissions and Mortality in a Large Municipal Healthcare System. JACC Heart Fail. 2016; 4(11):885–893.
10. Bahrami H, Kronmal R, Bluemke DA. Differences in the incidence of congestive heart failure by ethnicity: The multi-ethnic study of atherosclerosis. Arch Intern Med. 2008 ;168(19):2138–2145.
11. Aluli NE, Reyes PW, Brady SK et al. All-cause and CVD mortality in native Hawaiians. Diabetes Res ClinPract. 2010;89(1):65–71.
12. Mau MK, Sinclair K, Saito EP, Baumhofer KN, Kaholokula JK. Cardiometabolic health disparities in native Hawaiians and other Pacific Islanders. Epidemiol Rev. 2009;31:113–129.
13. Uchima O, Wu YY, Browne C, Braun KL. Disparities in Diabetes Prevalence Among Native Hawaiians/Other Pacific Islanders and Asians in Hawai'i.Prev Chronic Dis 2019; 16:180187.
14. Tung, WC. Diabetes among native Hawaiians and Pacific Islanders. Home Health Care Management and Practice. 2012;24(6), 309–311.
15. Siriwardhana C, Lim E, Davis J, Chen JJ.Progression of diabetes, ischemic heart disease, and chronic kidney disease in a three chronic conditions multistate model.BMC Public Health. 2018;18(1):752.
16. King GL, McNeely MJ, Thorpe LE, Mau ML, Ko J, Liu LL, et al. Understanding and addressing unique needs of diabetes in Asian Americans, native Hawaiians, and Pacific Islanders. Diabetes Care. 2012 ; 35(5):1181-8.
17. Sentell TL, Ahn HJ, Juarez DT, Tseng CW, Chen JJ, Salvail FR, et al. Comparison of potentially preventable hospitalizations related to diabetes among native Hawaiian, Chinese, Filipino, and Japanese elderly compared with whites, Hawai'i, December 2006-December 2010. Prev Chronic Dis 2013;10:E123.
18. Siriwardhana C, Lim E, Aggarwal L, Davis J, Hixon A, Chen JJ. Racial/Ethnic and County-level Disparity in Inpatient Utilization among Hawai'i Medicaid Population. Hawaii J Med Public Health. 2018;77(5):103–113.
19. Gamble JM1, Eurich DT, Ezekowitz JA, Kaul P, Quan H, McAlister FA. Patterns of care and outcomes differ for urban versus rural patients with newly diagnosed heart failure, even in a universal healthcare system. Circ Heart Fail. 2011 May;4(3):317-23.
20. Jin Y, Quan H, Cujec B, Johnson D. Rural and urban outcomes after hospitalization for congestive heart failure in Alberta, Canada. Cardfail. 2009;9(4): 278 – 285
21. Dickman SL, Himmelstein DU, Woolhandler S. Inequality and the health-care system in the USA. Lancet. 2017; 389(10077): 1431-1441.
22. Stone ML, LaPar DJ, Mulloy DP. Primary payer status is significantly associated with postoperative mortality, morbidity, and hospital resource utilization in pediatric surgical patients within the United States. J Pediatr Surg. 2013; 48(1):81–87.
23. Parikh-Patel A, Morris CR, Kizer KW. Disparities in quality of cancer care: The role of health insurance and population demographics. Medicine (Baltimore). 2017; 96(50): e9125.
24. Allen LA, SmoyerTomic KE, Wilson KL, Smith DM, Agodoa I. The inpatient experience and predictors of length of stay for patients hospitalized with systolic heart failure: Comparison by commercial, Medicaid, and Medicare payer type. J Med Econ. 2012;16(1):43–54.
25. Merry AH, Boer JM, Schouten LJ, Feskens EJ.Validity of coronary heart diseases and heart failure based on hospital discharge and mortality data in the Netherlands using the cardiovascular registry Maastricht cohort study. Eur J Epidemiol. 2009; 24(5):237-47.
26. Henderson T, Shepheard J, Sundararajan V. Quality of diagnosis and procedure coding in ICD-10 administrative data. Med Care. 2006;44(11):1011-9.
27. Díez-Villanueva P, Alfonso F. Heart failure in the elderly. J GeriatrCardiol. 2016;13(2):115–117.
28. Verderber A, Castelfranco AM, Nishioka D, Johnson KG. Cardiovascular risk factors and cardiac surgery outcomes in a multiethnic sample of men and women. Am J Crit Care. 1999; 8(3): 140-148.

29. Taira DA, Seto TB, Marciel C.Ethnic disparities in care following acute coronary syndromes among Asian Americans and Pacific Islanders during the initial hospitalization. Cell MolBiol (Noisy-le-grand). 2001; 47(7):1209-15.
30. T, Baker KK, Onaka A, Braun K. Low health literacy and poor health status in Asian Americans and Pacific Islanders in Hawai'i.J Health Commun. 2011;16 Suppl 3:279-94.
31. Hostetter CJ. Income Inequality and Native Hawaiian Communities in the Wake of the Great Recession: 2005-2013.
32. Yin J, Lurås H, Hagen TP. The effect of activity-based financing on hospital length of stay for elderly patients suffering from heart diseases in Norway. BMC Health Serv Res 13, 172 (2013).
33. Ideta TR, Lim E, Nakagawa K, Koenig MA. Racial and ethnic disparities in hospital mortality among ischemic stroke patients in hawaii. J Stroke Cerebrovasc Dis. 2018; 27(6): 1458-1465.
34. Ryan C, Shaw R, Pliam M, Zapolanski AJ, Murphy M, Valle HV, et al. Coronary heart disease in Filipino and Filipino-American patients: Prevalence of risk factors and outcomes of treatment. J Invasive Cardiol. 2000 ;12(3):134-9.
35. Jose PO, Frank AT, Kapphahn KI, Goldstein BA, Eggleston K, Hastings KG, et al. Cardiovascular disease mortality in Asian Americans. J Am CollCardiol. 2014; 64(23):2 486-94.
36. Araneta MR, Wingard DL, Barrett-Connor E. Type 2 diabetes and metabolic syndrome in Filipina-American women: A high-risk nonobese population. Diabetes Care. 2002; 25(3):494-9.
37. Park SY, Kang M, Wilkens LR. The Dietary Inflammatory Index and All-Cause, Cardiovascular Disease, and Cancer Mortality in the Multiethnic Cohort Study. Nutrients. 2018; 10(12): 1844.
38. Ueshima H, Okayama A, Saitoh S, Nakagawa H, Rodriguez B, Sakata K, et al. Differences in cardiovascular disease risk factors between japanese in japan and japanese-americans in hawaii: the interlipid study. journal of human hypertension. 2003; 17: 631–639.
39. Fang J, Madhavan S, Alderman MH.Cardiovascular mortality of Chinese in New York City.J Urban Health. 1999; 76(1): 51-61.
40. LaPar DJ, Bhamidipati CM, Mery CM. Primary payer status affects mortality for major surgical operations. Ann Surg. 2010; 252(3): 544–551
41. Prasad S, Sung B, Aggarwal BB. Age-associated chronic diseases require age-old medicine: Role of chronic inflammation. Prev Med. 2012;54: S29-37.
42. Admi H, Shadmi E, Baruch H1, Zisberg A.From research to reality: Minimizing the effects of hospitalization on older adults. Rambam Maimonides Med J. 2015;6(2):e0017.
43. Freeman WJ, Weiss AJ, Heslin KC. Overview of U.S. Hospital Stays in 2016: Variation by Geographic Region. HCUP Statistical Brief #246. 2018.
44. Mooney JJ, Raimundo K, Chang E, Broder MS. Hospital cost and length of stay in idiopathic pulmonary fibrosis. J Med Econ. 2017; 20(5): 518-524.
45. Salem K, ElKhateeb O.Gender-adjusted and age-adjusted economic inpatient burden of congestive heart failure: Cost and disability-adjusted life-year analysis. ESC Heart Fail. 2017; 4(3): 259-265.
46. Yamamoto DH. Health Care Costs—From Birth to Death, Health Care Cost Institute—Society of Actuaries, 2013
47. Husaini BA, Sherkat DE, Levine R, Bragg R, Holzer C, Anderson K, et al. Race, gender, and health care service utilization and costs among Medicare elderly with psychiatric diagnoses. J Aging Health. 2002;14(1):79-95.
48. Win TT, Davis HT, Laskey WK. Mortality. Among patients hospitalized with heart failure and diabetes mellitus: results from the national inpatient sample 2000 to 2010. Circ Heart Fail. 2016;9(5): e003023.
49. Milcent C, Dormont B, Durand-Zaleski I, Steg PG. Gender differences in hospital mortality and use of percutaneous coronary intervention in acute myocardial infarction: microsimulation analysis of the 1999 nationwide French hospitals database. Circulation. 2007;115(7): 833-9.
50. Kim HL, Jang JS, Kim MA, Seo JB.Gender differences of in-hospital outcomes in patients undergoing percutaneous coronary intervention in the drug-eluting stent era. Medicine (Baltimore). 2019; 98(20): e15557.
51. Stein GY, Ben-Gal T, Kremer A, Bental T. Gender-related differences in hospitalized heart failure patients. Eur J Heart Fail. 2013; 15(7): 734-41.
52. Ambrose AJ, Arakawa RY, Greidanus BD. Geographical maldistribution of native Hawaiian and other Pacific Islander physicians in Hawai'i. Hawaii J Med Public Health. 2012; 71: 13–20.
53. Withy K. Annual report on findings from the Hawai'i physician workforce assessment project, Report to the 2016 legislature, John A. Burns School of Medicine, Area Health Education Center, 2015.
54. Joynt KE, Orav EJ, Jha AK. The association between hospital volume and processes, outcomes, and costs of care for congestive heart failure. Ann Intern Med. 2011; 154(2): 94–102.
55. New Y, Health H, Corporation S. Medicare Hospital Quality Chartbook Performance Report on Outcome Measures: September 2014. New Haven, CT. 2014.
56. Dharmarajan. Trajectories of risk after hospitalization for heart failure, acute myocardial infarction, or pneumonia: Retrospective cohort study. BMJ 2015; 350: h411
57. Sud M, Yu B, Wijeysundera HC, Association between short or Long Length of Stay and 30-Day Readmission and Mortality in Hospitalized Patients With Heart Failure. JACC Heart Fail. 2017; 5(8): 578-588.
58. US Census Bureau. 2010 Census. US Census Bureau. 2010
59. Columbo JA, Kang R, Trooboff SW, Jahn KS, Martinez CJ.Validating Publicly Available Crosswalks for Translating ICD-9 to ICD-10 Diagnosis Codes for Cardiovascular Outcomes Research.CircCardiovascQual Outcomes. 2018; 11(10): e004782.