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Examining Factors Associated With Nonadherence And Identifying Providers Caring For Nonadherent Subgroups

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Abstract

Objectives—To examine racial/ethnic and regional differences in medication adherence in patients with diabetes taking oral anti-diabetic, anti-hypertensive, and cholesterol lowering medications and to identify the pharmacies and prescribers who serve these communities.

Methods—Administrative claims data was analyzed for members enrolled in a large health plan in Hawaii (2008-2010) with diabetes mellitus who were taking three types of medications: 1) oral anti-diabetic medications; 2) anti-hypertensive medications; 3) cholesterol lowering medications (n=5136). The primary outcome was medication adherence based on medication possession ratios. Multivariable logistic regression models were estimated to examine the association between race/ethnicity and region to adherence to each drug class separately, followed by non-adherence to all three. Covariates included age, gender, education level, chronic conditions, copayment level, and number of prescribers and pharmacies from which the patients received their medications.

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Key Findings—After adjustment for other factors, Filipinos [OR=0.58, 95%CI(0.45,0.74)], Native Hawaiians [OR=0.74, 95%CI(0.56,0.98)], and people of other race [OR=0.67, 95%CI(0.55,0.82)] were significantly less adherent to anti-diabetic and anti-hypertensive medications than Japanese. For cholesterol-lowering medications, all racial and ethnic groups were significantly less adherent than Japanese, except mixed race. We also found that different racial/ethnic groups tended to use different pharmacies and prescribers, particularly in rural areas

Conclusion—Adherence differed by race/ethnicity as well as age and region. Qualitative research involving subgroups (e.g. Filipinos, Native Hawaiians, people under age 50) is needed to identify how to adapt and enhance the effects of interventions shown to be efficacious in prior studies.

Keywords

Pharmaceutical HSR; Health Services Research; Outcomes Research

Introduction

Although medication therapy has been effective in improving glycemic control as well as blood pressure and cholesterol levels,¹⁻⁵ many patients fail to fill prescribed medications, take less than recommended, or do not refill their prescriptions. Approximately 20 to 30 percent of prescriptions are never filled, and about half of chronic disease medications are not taken as prescribed.^{6,7} Prior studies have documented the relationship between poor adherence and insufficient glycemic control, increased morbidity and mortality, emergency department visits and hospitalizations, higher medical care costs, and increased workplace absenteeism.⁸⁻¹⁴

Medication adherence has been shown to differ by race/ethnicity. A recent study of antihypertensives found nonwhites to be more likely to be non-adherent [Black Odds Ratio: 1.54 (95% CI: 1.35, 1.75); Asian OR: 1.13 (95% CI:1.00,1.28); Hispanic OR: 1.48 (95% CI: 1.33,1.65).]¹⁵ Similar racial and ethnic disparities have been found with regard to adherence to antidiabetic medications and cholesterol-lowering ones.^{16,17}

The goal of this study is to examine regional variation and racial/ethnic differences among Asian Pacific Islander sub-groups in medication adherence in patients with diabetes taking oral anti-diabetic, anti-hypertensive, and cholesterol lowering medications in order to identify potential sub-populations in need of targeted interventions. We hypothesize that Asian and Pacific Islander adherence will be lower than that of whites. In addition to examining the significance and strength of associations between medication adherence and racial/ethnic subgroups and regions, we identified the pharmacies and prescribers who serve these sub-populations in order to better understand where interventions might best be delivered in communities and clinical settings. We also examined if the number of prescribers from whom patients are receiving care affects adherence. Our hypothesis is that fewer prescribers might lead to greater adherence as prior research has shown greater continuity leads to improved adherence.^{18,19} Studying the drug use pattern of patients with diabetes related to race/ethnicity and region is important to guide development of targeted

interventions to improve medication adherence and reduce health disparities, morbidity and mortality.

Methodology

This retrospective observational study analyzed administrative claims data on members enrolled in a large health plan in Hawaii (2008-2010) with diabetes mellitus who were taking three types of medications: 1) oral anti-diabetic medications; 2) anti-hypertensive medications; 3) cholesterol lowering medications (n=5136). The insurer identified patients with diabetes based on criteria from the Health Effectiveness Data and Information set (HEDIS).

Ethnicity was based on self-report from member satisfaction surveys. Race/ethnicity was categorized for the five most common Hawaii ethnicities (Japanese, Native Hawaiians, Whites, Filipinos, and Chinese). People of mixed race/ethnicity were classified as “mixed race”, except for Native Hawaiians. Because almost all Native Hawaiians are of mixed race/ethnicity, anyone checking “Native Hawaiian” was classified as such regardless of whatever other race/ethnic groups they reported. People not falling into any of these groups were categorized as “other race/ethnicity.” Because Japanese were the largest ethnic subgroup and had the highest adherence rates, Japanese were chosen as the referent population for comparisons. Education level was also obtained from survey data and categorized as less than high school, high school graduate, some college, college graduate, and post-college education.

We also calculated the average number of prescribers who prescribed medication to the patient over the course of the three years and the average number of pharmacies at which they received their medications for each region. In addition, since copayment level is known to impact adherence rates,²⁰⁻²⁵ we calculated copayment per month by type of medication as total patient copayment divided by total days supply for their medications, multiplied by 30 days.

Our primary outcome was medication adherence, calculated based on medication possession ratios (MPR). MPR is the ratio of the number of days for which a patient has medication on hand divided by the total number of days a patient was enrolled in a drug plan. For this study, the numerator included the summation of the days supply for all of a patient's filled prescriptions for each type of medication (i.e. oral anti-diabetic, antihypertensive, dyslipidemia). Hence, it didn't matter if patients switched between specific medications (e.g. from atorvastatin to simvastatin); as long as they had a medication of a particular type in their possession, they were considered adherent. For each patient, the MPR was averaged over the three years (2008-2010) to arrive at a single MPR for each type of medication for every patient. MPR ranges between 0 and 1, with 1 representing perfect adherence. For the purposes of analyses, we defined adherence as an MPR of at least 0.8, or an 80% possession ratio as is commonly done in studies of this type.^{15,26}

T-tests and chi-squared tests were used to examine differences in demographic characteristics, unadjusted adherence rates, and number of prescribers and pharmacies at

which the patients received their prescriptions, as appropriate. We estimated multivariable logistic regression models to assess the association between race/ethnicity and region and adherence to anti-diabetic, anti-hypertensive, and cholesterol medications. Models for each type of medication were estimated separately. We then examined the odds ratios of non-adherence to all three types of medications in an additional model. Covariates included age, gender, education level, chronic conditions [coronary artery disease, heart failure, chronic kidney disease, chronic obstructive pulmonary disease], copayment level, and number of prescribers and pharmacies from which they received their medications. These variables were selected a priori based both on clinical significance and prior research documenting their relation to medication adherence and they remained in the model regardless of their level of significance. Results are presented as odds ratios and confidence intervals fit in Stata V13 (College Station, TX). The University of Hawaii institutional review board (IRB) granted the study an exemption from IRB review.

Results

Race/ethnicity was significantly associated with all demographic factors examined (Table 1). Mean age ranged from 63.3 years for patients of mixed race to 71.5 years for Chinese. Percent of females ranged from 41.3% among mixed race to 58.9% for those of other race. The percent of patients with a high school education or less ranged from 56.5% for Native Hawaiians to 39.9% for Whites. In addition, only 1.9% of Filipinos had post college education compared to 11.1% of whites.

In terms of unadjusted chronic disease prevalence, coronary heart disease was most prevalent for Japanese, heart failure was most commonly found in Native Hawaiians, chronic obstructive pulmonary disease prevalence was highest among whites and Native Hawaiians, and chronic kidney disease prevalence was highest among Chinese (Table 1). Ethnic groups also tended to be located in different geographic regions. Over 71% of Chinese lived in Honolulu. In addition, 46.2% of Filipinos and 39.6% of Native Hawaiians lived on Oahu outside of Honolulu. Whites were most evenly spread across regions, with less than 31% living in any one region, while 78% of Japanese lived on the island of Oahu, either in Honolulu or outside of the city.

Prescriber and Pharmacy Count

While the number of prescribers of medication and pharmacies from which they received their medication differed significantly by race and ethnicity, the magnitude of these differences was small. The number of prescribers ranged from 3.0 for mixed race individuals to 3.6 for Whites, while the number of pharmacies ranged from 2.7 for mixed race individuals to 3.2 for Whites and Chinese.

Unadjusted Medication Adherence Rates

Significant and substantial differences were also found for medication adherence across racial/ethnic groups (Table 1). For oral anti-diabetic medications, adherence ranged from 67.6% for Filipinos to 78.9% for Japanese, anti-hypertensive adherence ranged from 51.8% from 72.1% for Filipinos to 84.0% for Japanese, and cholesterol-lowering drug adherence

ranged from 51.8% for Filipinos to 72.7% for Japanese. Non-adherence to all three types of medications was highest among those of mixed race (16.0%) and Filipinos (15.8%) compared to 7.0% among Japanese. For all four measures of adherence, differences across racial/ethnic groups were significant at $p < 0.001$.

Multivariable Logistic Regression Results: Factors Affecting Medication Adherence

After adjustment for other factors, Filipinos [OR=0.58, 95%CI(0.45,0.74)], Native Hawaiians [OR=0.74, 95%CI(0.56,0.98)], and people of other race [OR=0.67, 95%CI(0.55,0.82)] were significantly less adherent to anti-diabetic medications than Japanese (Table 2). Similarly, Filipinos [OR=0.51, 95%CI(0.39,0.67)], Native Hawaiians [OR=0.68, 95%CI(0.50,0.93)], and people of other race [OR=0.60, 95%CI(0.48,0.75)] were also significantly less adherent than Japanese to anti-hypertensive medications. For anti-hypertensive medications, Chinese [OR=0.51, 95%CI(0.39,0.84)] were also less adherent than Japanese. For cholesterol-lowering medications, all racial and ethnic groups were significantly less adherent than Japanese, except mixed race individuals who had similar adherence to Japanese.

There were only a few significant differences in adherence related to region, after adjustment for other factors (Table 2). Patients from Kauai [OR=0.66, 95%CI(0.52,0.85)] and Maui [OR=0.77, 95%CI(0.61,0.98)] were less adherent to anti-diabetic medications than patients from Honolulu. Patients from Maui [OR=0.78, 95%CI(0.62,0.97)] were also significantly less adherent than patients from Honolulu to cholesterol-lowering medication.

For all types of medication, age was significantly related to adherence with all groups more adherent than the youngest group (patients less than age 50). Being female was associated with worse adherence for anti-diabetic and cholesterol-lowering medications. Education was not significantly associated with adherence, except in that high school graduates with some college were more adherent to cholesterol lowering medications than those with less than a high school education. Having a chronic condition was not significantly associated with adherence to anti-diabetic or cholesterol-lowering medications; however, having coronary artery disease or heart failure was associated with greater adherence to anti-hypertensive medications.

A higher number of prescribers was associated with increased adherence for anti-diabetic medications but not to other types of medication, while number of pharmacies was not significantly related to adherence.

Copayment levels were significantly associated with adherence, with higher copayments related to decreased adherence. The impact of copayment was strongest for anti-hypertensive medications. Compared to patients paying less than \$10 per month in copayments, patients paying \$40 or more were significantly less adherent for anti-diabetic [OR=0.54, 95%CI(0.32,0.90)], anti-hypertensive [OR=0.34, 95%CI(0.20,0.57)], and cholesterol-lowering [OR=0.52, 95%CI(0.32,0.84)] medications.

Multivariable Logistic Regression Results: Nonadherence to All Three Types of Medication

Compared to Japanese, Filipinos [OR=2.25, 95%CI(1.59,3.19)], Native Hawaiians [OR=1.98, 95%CI(1.34,2.93)], whites [OR=1.69, 95%CI(1.05,2.74)], and people of other race [OR=2.09, 95%CI(1.55,2.81)] were significantly more likely to be non-adherent to all three types of medications (Table 2). In terms of region, patients on Maui [OR=1.40, 95%CI(1.02,1.91)] and on Oahu (outside of Honolulu) [OR=1.26, 95%CI(1.03,1.55)] were significantly more likely to be non-adherent to all three types of medication than those living in Honolulu.

Other demographic factors and copayment level were also significantly associated with non-adherence to all three types of medication (Table 2). Older people were less likely to be non-adherent, while females were more likely to be non-adherent. Moreover, an increased copayment level was significantly related to likelihood of non-adherence to all three types of medication.

Pharmacy Use by Region and Race/Ethnicity

In order to determine how easy it might be to utilize prescribers to target specific racial and ethnic groups in a given region, we examined how many prescriptions were filled at each pharmacy in each region.

In this manuscript, one region has been examined for illustrative purposes (Figure). For the chosen region (Other Oahu), the top 5 pharmacies included Longs, Times, and Kmart for both Native Hawaiians and Filipinos. For Native Hawaiians, the top 5 included Precision RX and Medco, while for Filipinos, the top pharmacies included Walmart and Costco. As Native Hawaiians and Filipinos had the lowest adherence (Table 1) and most likely to be non-adherent to all three types of drugs, identifying the pharmacies they use may be particularly important to targeting interventions.

Prescribers by Region and Race/Ethnicity

Similarly, we examined which prescribers prescribed medication by racial and ethnic group in each region (data not shown in tables). For East-Hawaii, there are a few prescribers who provide the vast majority of prescriptions for Chinese. For Native Hawaiians and Japanese, the top five prescribers prescribe almost half of all prescriptions. Three of the top five prescribers for Native Hawaiians are not top prescribers for any other groups. In general, top prescribers for the different ethnic groups differ. The two groups that have the most in common are Filipinos and whites for whom three of the top five prescribers are the same. For West Hawaii, three of the top five prescribers were the same for Native Hawaiians, Filipinos, and Japanese. Chinese tended to see a different set of prescribers than other groups but 5 prescribers prescribed 97% of their prescriptions. For Kauai, two of the top five prescribers were the same for Native Hawaiians and Filipinos. In Maui county, 66% of prescriptions were from the top 5 prescribers for Chinese, but that percent was 41% or less for other groups. There was a lack of significant overlap in top Maui county prescribers between the groups. For Honolulu, 21% of prescriptions for whites, Chinese, and Filipinos were from the top 5 prescribers, while 14% of those for Native Hawaiians and Japanese were from the top five prescribers. There was also little overlap in top Honolulu prescribers

between groups. For other Oahu, two of the top prescribers were the same for Filipinos and Native Hawaiians. Otherwise, there was not a lot of overlap. Moreover, only a small percentage of prescriptions was given by the top 5 prescribers for each group.

Discussion

In our study of over 5000 patients with diabetes taking three types of medication (anti-diabetic, anti-hypertensive, cholesterol lowering), we found racial/ethnic and regional differences in medication adherence, even after adjustment for other factors. Filipino and Native Hawaiian patients were the least adherent to medications as were patients from Maui, Kauai, and Oahu (outside of Honolulu). Other factors significantly related to adherence include age, with older patients being more adherent, and gender, with females being less adherent. As expected, higher copayment levels were associated with lower adherence rates across all types of medication, but the effect was particularly pronounced for anti-hypertensive medications.

Prior studies have found decreased adherence was associated with increasing copayment level and younger age.²⁰⁻²⁵ Moreover, previous research has identified disparities in adherence related to race and ethnicity.^{15, 27-32} The strength of our study is its ability to control for a large array of factors including copayment level and demographic factors and its identification of specific pharmacies and prescribers who might facilitate interventions for each racial/ethnic group in each region.

Limitations to the study include that it only included patients in Hawaii so may generalize to other areas. In addition, information was not available in the administrative data on reasons for non-adherence, which would be helpful in guiding interventions. Moreover, the focus was on patients taking three therapeutic classes of medications for three years; hence, we have not examined factors related to never filling a first medication, which has been shown to account for 20 to 30 percent of non-adherence.⁶

Improvements in adherence have been shown to result from several types of interventions including policy interventions, telephonic and text message follow-up, as well as educational interventions by pharmacists.³³⁻³⁹ The effect size and sustainability of these impacts on adherence and subsequent patient outcomes, however, has been somewhat modest.

Conclusion

Future interventions could be designed based on our findings as our study has identified subgroups (Filipinos, Native Hawaiians, females, people under age 50, those living on Maui, Kauai, and Oahu, outside of Honolulu) that might benefit from targeted medication adherence initiatives. Also, as our findings suggest that certain prescribers (pharmacies and physicians) tend to treat members of specific racial/ethnic groups, collaborating with pharmacies and prescribers who tend to treat specific subgroups might lead to sustainable improvements. Qualitative research involving these subgroups is needed to identify how to adapt and enhance potentially effective interventions.

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References

- Handelsman Y, Bloomgarden ZT, Grunberger G, Umpierrez G, Zimmerman RS, Bailey TS, et al. American association of clinical endocrinologists and American college of endocrinology – clinical practice guidelines for developing a diabetes mellitus comprehensive care plan – 2015. *Endocr Pract.* 2015; 21(suppl 1):1–87. [PubMed: 25869408]
- Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, et al. Management of hyperglycemia in type 2 diabetes, 2015: a patient-centered approach: update to a position statement of the American Diabetes Association and the European Association for the study of diabetes. *Diabetes Care.* 2015; 38(1):140–149. [PubMed: 25538310]
- Amarenco P, Labreuche J. Lipid management in the prevention of stroke: review and updated meta-analysis of statins for stroke prevention. *Lancet Neurol.* 2009; 8(5):453–463. [PubMed: 19375663]
- Baigent C, Keech A, Kearney PM, Blackwell L, Buck G, Pollicino C, et al. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. *Lancet.* 2005; 366(9493):1267–1278. [PubMed: 16214597]
- Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. *BMJ.* 2009; 338:b1665. [PubMed: 19454737]
- Colombi AM, Yu-Isenberg K, Priest J. The effects of health plan copayments on adherence to oral diabetes medication and health resource utilization. *J Occup Environ Med.* 2008; 50(5):535–541. [PubMed: 18469622]
- Gibson TB, Song X, Alemayehu B, Wang SS, Waddell JL, Bouchard JR, et al. Cost sharing, adherence, and health outcomes in patients with diabetes. *Am J Manag Care.* 2010; 16(8):589–600. [PubMed: 20712392]
- Peterson AM, Takiya L, Finley R. Meta-analysis of trials of interventions to improve medication adherence. *Am J Health Syst Pharm.* 2003; 60(7):657–65. PMID: 12701547. [PubMed: 12701547]
- Haynes RB, Ackloo E, Sahota N, McDonald HP, Yao X. Interventions for enhancing medication adherence. *Cochrane Database Syst Rev.* 2008; (2):CD000011. [PubMed: 18425859]
- Ratanawongsa N, Karter AJ, Parker MM, Lyles CR, Heisler M, Moffet HH, et al. Communication and medication refill adherence: the Diabetes Study of Northern California. *JAMA Intern Med.* 2013; 173(3):210–218. [PubMed: 23277199]
- Tiv M, Viel JF, Mauny F, Eschwege E, Weill A, Fournier C, et al. Medication adherence in type 2 diabetes: the ENTRED study 2007, a French population-based study. *PLoS One.* 2012; 7(3):e32412. [PubMed: 22403654]
- Currie CJ, Peyrot M, Morgan CL, Poole CD, Jenkins-Jones S, Rubin RR, et al. The impact of treatment noncompliance on mortality in people with type 2 diabetes. *Diabetes Care.* 2012; 35(6):1279–1284. [PubMed: 22511257]
- Ho PM, Rumsfeld JS, Masoudi FA, McClure DI, Plomondon ME, Steiner JF, et al. Effect of medication nonadherence on hospitalization and mortality among patients with diabetes mellitus. *Arch Intern Med.* 2006; 166(17):1836–1841. [PubMed: 17000939]
- Lind M, Garcia-Rodriguez LA, Booth GL, Cea-Soriano L, Shah BR, Ekeröth G, et al. Mortality trends in patients with and without diabetes in Ontario, Canada and the UK from 1996 to 2009: a population-based study. *Diabetologia.* 2013; 56(12):2601–2608. [PubMed: 24114114]
- Adams AS, Uratsu C, Dyer W, Magid D, O'Connor P, Beck A, et al. Health System Factors and Antihypertensive Adherence in a Diverse Cohort of New Users. *JAMA Intern Med.* 2013; 173(1):54–61. [PubMed: 23229831]

16. Adams AS, Trinacty CM, Zhang F, Kleinman K, Grant RW, Meigs JB, et al. Medication Adherence and Racial Differences in HbA1c Control. *Diabetes Care*. 2008; 31(5):916–921. [PubMed: 18235050]
17. Saffar D, Williams LK, Lafata JE, Divine G, Pladevall M. Racial Disparities in Lipid Control in Patients With Diabetes. *Am J Manag Care*. 2012; 18(6):303–311. [PubMed: 22774998]
18. Maciejewski ML, Hammill BG, Bayliss EA, Ding L, Voils CI, Curtis LH, et al. Prescriber Continuity and Disease Control of Older Adults. *Med Care*. 2017; 55(4):405–410. [PubMed: 27755393]
19. Hansen RA, Voils CI, Farley JF, Powers BJ, Sanders LL, Sleath B, et al. Prescriber continuity and medication adherence for complex patients. *Ann Pharmacother*. 2015 Mar; 49(3):293–302. [PubMed: 25549627]
20. Taira DA, Wong K, Frech-Tamas F, Chung RS. Copayment Level and Compliance with Antihypertensive Medication: Analysis and Policy Implications for Managed Care. *Am J Manag Care*. 2006; 12(11):678–83. [PubMed: 17090224]
21. Aziz H, Hatah E, Makmor Bakry M, Islahudin F. How payment scheme affects patients' adherence to medications? A systematic review. *Patient Pref Adherence*. 2016; 10:837–50.
22. Luiza VL, Chaves LA, Silva RM, Emmerick IC, Chaves GC, Fonseca de Araujo SC, et al. Pharmaceutical policies: effects of cap and co-payment on rational use of medicines. *Cochrane Database Syst Rev*. 2015; 5:CD007017.
23. Mann BS, Barnieh L, Tang K, Campbell DJ, Clement F, Hemmelgarn B, et al. Association between drug insurance cost sharing strategies and outcomes in patients with chronic diseases: a systematic review. *PloS One*. 2014; 9(3):e89168. [PubMed: 24667163]
24. Colombi AM, Yu-Isenberg K, Priest J. The effects of health plan copayments on adherence to oral diabetes medication and health resource utilization. *J Occup Environ Med*. 2008; 50(5):535–541. [PubMed: 18469622]
25. Gibson TB, Song X, Alemayehu B, Wang SS, Waddell JL, Bouchard JR, et al. Cost sharing, adherence, and health outcomes in patients with diabetes. *Am J Manag Care*. 2010; 16(8):589–600. [PubMed: 20712392]
26. DiMatteo MR, Giordani PJ, Lepper HS, Croghan TW. Patient adherence and medical treatment outcomes: a meta-analysis. *Med Care*. 2002; 40:794–811. [PubMed: 12218770]
27. Yang Y, Thumula V, Pace PF, Banahan BF III, Wilkin NE, Lobb WB. Predictors of medication nonadherence among patients with diabetes in Medicare Part D programs: a retrospective cohort study. *Clin Ther*. 2009; 31(10):2178–2188. [PubMed: 19922889]
28. Dunbar JJ, Rohay JM. Predictors of medication adherence: fact or artifact. *J Behav Med*. 2016; 39(6):957–968. [PubMed: 27306683]
29. Trinacty CM, Adams AS, Soumerai SB, Zhang F, Meigs JB, Pietter JD, et al. Racial differences in long-term adherence to oral antidiabetic drug therapy: a longitudinal cohort study. *BMC Health Serv Res*. 2009; 9:24. [PubMed: 19200387]
30. Taira DA, Gelber RP, Davis J, Gronley K, Chung RS, Seto TB. Anti-hypertensive Adherence and Drug Class among Asian Pacific Americans. *Ethnicity and Health*. 2007; 12(3):265–281. [PubMed: 17454100]
31. Lee R, Taira DA. Adherence to oral hypoglycemic agents in Hawaii. *Prev Chronic Dis*. 2005; 2(2): 1–7.
32. Juarez DT, Williams AE, Chen C, Daida YG, Tateishi S, Trinacty CM, et al. Factors Affecting Medication Adherence Trajectories for Patients With Cardiovascular Disease. *Am J Manag Care*. 2015; 21(3):e197–e205. [PubMed: 26014307]
33. Walker EA, Shmukler C, Ullman R, Blanco E, Scollan-Koliopoulus M, Cohen HW. Results of a successful telephonic intervention to improve diabetes control in urban adults: a randomized trial. *Diabetes Care*. 2011; 34(1):2–7. [PubMed: 21193619]
34. Lawrence DB, Allison W, Chen JC, Demand M. Improving medication adherence with a targeted, technology-driven disease management intervention. *Dis Manag*. 2008; 11(3):141–144. [PubMed: 18498220]
35. Thiebaud P, Demand M, Wolf SA, Alipuria LL, Ye Q, Gutierrez PR. Impact of disease management on utilization and adherence with drugs and tests: the case of diabetes treatment in

- the Florida: a Healthy State (FAHS) program. *Diabetes Care*. 2008; 31(9):1717–1722. [PubMed: 18523144]
36. Wolever RQ, Dreusicke M, Fikkan J, Hawkins TV, Yeung S, Wakefield J, et al. Integrative health coaching for patients with type 2 diabetes: a randomized clinical trial. *Diabetes Educ*. 2010; 36:629–639. [PubMed: 20534872]
37. Odegard PS, Carpinito G, Christensen DB. Medication adherence program: adherence challenges and interventions in type 2 diabetes. *J Am Pharm Assoc*. 2013; 53(3):267–272.
38. Odegard PS, Gray SL. Barriers to medication adherence in poorly controlled diabetes mellitus. *Diabetes Educ*. 2008; 34(4):692–697. [PubMed: 18669811]
39. Vervloet M, van Dijk L, Santen-Reestman J, Van Vlijmen B, van Wingerden P, Bouvy ML, et al. SMS reminders improve adherence to oral medication in type 2 diabetes patients who are real time electronically monitored. *Int J Med Inform*. 2012; 81(9):594–604. [PubMed: 22652012]

Figure.
Prescriptions Filled by Pharmacy and Race/Ethnicity For One Region of Hawaii

Table 1

Patient demographic characteristics, medication adherence and number of providers seen related to race and ethnicity.

	White	Native Hawaiian	Japanese	Chinese	Filipino	Mixed Race	Other Race	p-value
N	246	366	1,184	184	444	2,576	163	
Age (SD)	69.5 (9.9)	65.7 (10.4)	70.3 (11.6)	71.5 (11.8)	66.3 (10.7)	63.3 (11.6)	65.0 (10.0)	<0.001
Female (%)	50.0%	51.4%	53.4%	50.5%	55.0%	41.3%	58.9%	<0.001
Education								<0.001
High school or less	39.9%	56.5%	45.4%	42.7%	52.4%	50.9%	47.8%	
Some college	32.5%	33.6%	31.2%	25.8%	30.5%	21.9%	32.1%	
College graduate	16.5%	6.6%	17.2%	23.0%	15.3%	22.8%	15.7%	
Post college	11.1%	3.3%	6.2%	8.4%	1.9%	4.4%	4.4%	
Chronic conditions								
Coronary artery disease	37.0%	30.9%	29.1%	34.8%	22.8%	22.1%	30.7%	<0.001
Congestive heart failure	15.0%	17.5%	8.7%	7.6%	9.2%	7.7%	8.0%	<0.001
COPD	6.1%	6.0%	3.0%	2.7%	5.2%	3.0%	1.2%	0.002
Chronic kidney disease	4.5%	7.4%	5.7%	12.0%	6.3%	4.5%	8.0%	<0.001
Region								<0.001
Hawaii – East	17.1%	10.9%	7.6%	1.6%	6.5%	7.0%	10.4%	
Hawaii – West	9.4%	9.0%	2.6%	1.1%	3.2%	3.8%	4.3%	
Kauai	9.8%	8.7%	6.2%	1.6%	12.2%	8.0%	8.6%	
Maui	12.6%	12.6%	5.7%	2.2%	15.1%	8.1%	9.8%	
Oahu – Honolulu	20.7%	19.1%	37.2%	71.2%	16.9%	33.2%	23.3%	
Oahu – Other	30.5%	39.6%	40.8%	22.3%	46.2%	39.9%	43.6%	
Prescriber count	3.6 (2.0)	3.3 (1.8)	3.3 (1.8)	3.5 (1.9)	3.1 (1.7)	3.0 (1.7)	3.3 (1.9)	<0.001
Pharmacy count	3.2 (1.8)	3.0 (1.7)	3.0 (1.6)	3.2 (1.7)	2.8 (1.6)	2.7 (1.5)	2.9 (1.6)	<0.001
Medication adherence (%)								
Diabetes	74.4%	73.8%	78.9%	78.3%	67.6%	72.0%	81.6%	<0.001
Hypertension	82.9%	79.0%	84.0%	75.5%	72.1%	73.6%	82.8%	<0.001
Cholesterol lowering	64.2%	60.4%	72.7%	63.6%	51.8%	59.5%	64.4%	<0.001
Non-adherent to all three	10.2%	13.1%	7.0%	10.3%	15.8%	16.0%	8.6%	<0.001

Table 2
Odds of adherence related to demographic characteristics, number of providers seen, and copayment.

	Oral Diabetes		Hypertension		Cholesterol-lowering		Non-adherent to all 3	
	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval
Age								
Less than 50	1		1		1		1	
50-64	1.46	1.15	1.49	1.18	1.41	1.13	0.61	0.47
65-79	1.85	1.44	2.20	1.70	1.73	1.37	0.36	0.27
80+	1.41	1.05	2.02	1.49	1.75	1.33	0.43	0.30
Female	0.82	0.72	0.88	0.77	0.78	0.69	1.21	1.01
Education								
High school graduate	1		1		1		1	
Some college	0.94	0.76	1.17	0.93	1.08	0.89	0.81	0.60
College graduate	0.90	0.69	1.01	0.76	1.28	1.00	1.03	0.72
Post college	1.08	0.70	0.94	0.61	1.22	0.83	0.93	0.51
Race/ethnicity								
Japanese	1		1		1		1	
Chinese	0.96	0.65	0.58	0.39	0.64	0.46	1.60	0.94
White	0.73	0.52	0.84	0.57	0.67	0.50	1.69	1.05
Native Hawaiian	0.74	0.56	0.68	0.50	0.60	0.47	1.98	1.34
Filipino	0.58	0.45	0.51	0.39	0.43	0.34	2.25	1.59
Mixed race	1.17	0.77	0.93	0.60	0.71	0.50	1.19	0.65
Other race	0.67	0.55	0.60	0.48	0.61	0.51	2.09	1.55
Chronic conditions								
Coronary artery disease	1.00	0.85	1.30	1.09	1.05	0.91	0.87	0.70
Congestive heart failure	0.93	0.73	1.47	1.11	0.89	0.72	0.92	0.65
COPD	0.81	0.58	0.94	0.65	1.10	0.80	1.42	0.93
CKD	0.72	0.55	1.05	0.77	1.02	0.79	1.00	0.67
Region								
Honolulu	1		1		1		1	

	Oral Diabetes		Hypertension		Cholesterol-lowering		Non-adherent to all 3		
	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval	Odds Ratio	95% Conf. Interval	
East Hawaii	1.02	0.79	1.33	0.85	1.51	0.83	0.95	0.66	1.37
West Hawaii	0.90	0.64	1.25	0.59	1.19	0.74	1.12	0.72	1.75
Kauai	0.66	0.52	0.85	0.76	1.31	0.73	1.20	0.85	1.69
Maui	0.77	0.61	0.98	0.74	1.24	0.62	1.40	1.02	1.91
Other Oahu	0.91	0.78	1.06	0.74	1.02	0.88	1.26	1.03	1.55
Number of prescribers	1.02	1.00	1.04	0.98	1.02	0.97	0.97	0.95	1.00
Number of pharmacies	1.02	0.97	1.06	0.95	1.04	0.98	0.96	0.90	1.01
Copayment per month									
Less than \$10	1			1			1		
\$10-\$24	0.73	0.64	0.84	0.66	0.88	0.71	1.28	1.07	1.52
\$25-\$39	0.70	0.53	0.91	0.49	0.85	0.54	1.36	0.95	1.95
\$40 or more	0.54	0.32	0.90	0.20	0.57	0.32	2.39	1.26	4.52