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The Burden of Diagnosed and Undiagnosed Diabetes in Native Hawaiian and Asian American Hospitalized Patients

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Abstract

Aims—Little is known about diabetes in hospitalized Native Hawaiians and Asian Americans. We determined the burden of diabetes (both diagnosed and undiagnosed) among hospitalized Native Hawaiian, Asian (Filipino, Chinese, Japanese), and White patients.

Methods—Diagnosed diabetes was determined from discharge data from a major medical center in Hawai'i during 2007–2008. Potentially undiagnosed diabetes was determined by Hemoglobin A1c ≥6.5% or glucose ≥200 mg/dl values for those without diagnosed diabetes. Multivariable log-binomial models predicted diabetes (potentially undiagnosed and diagnosed, separately) controlling for socio-demographic factors.

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Conflicts of Interest Statement

Conflicts of interest: none

Results—Of 17,828 hospitalized patients, 3.4% had potentially undiagnosed diabetes and 30.5% had diagnosed diabetes. In multivariable models compared to Whites, Native Hawaiian and all Asian subgroups had significantly higher percentages of diagnosed diabetes, but not of potentially undiagnosed diabetes. Potentially undiagnosed diabetes was associated with significantly more hospitalizations during the study period compared to both those without diabetes and those with diagnosed diabetes. In all racial/ethnic groups, those with potentially undiagnosed diabetes also had the longest length of stay and were more likely to die during the hospitalization.

Conclusions—Hospitalized Native Hawaiians (41%) and Asian subgroups had significantly higher overall diabetes burdens compared to Whites (23%). Potentially undiagnosed diabetes was associated with poor outcomes. Hospitalized patients, irrespective of race/ethnicity, may require more effective inpatient identification and management of previously undiagnosed diabetes to improve clinical outcomes.

Keywords

Asian American; Diabetes; Hospitalization; Native Hawaiian

1. Introduction

Native Hawaiians and Asian Americans are two of the fastest growing populations in the United States (US) [1]. Many members of these racial/ethnic groups have higher rates of diabetes than non-Hispanic Whites [2]. Little is known about the prevalence of diabetes in hospitalized Native Hawaiians and Asian American subgroups.

Understanding the full diabetes burden among hospitalized Native Hawaiian and Asian American populations is important because diabetes contributes to poor health outcomes and high health care costs [3,4]. In the US, approximately 16–25% of hospitalized patients have diagnosed diabetes [5,6]. Previous studies on diabetes prevalence among hospitalized patients have either not included, or have not disaggregated, heterogeneous Asian and Pacific Islander subgroups [6–8].

Estimates of diabetes prevalence in hospitalized patient populations are complicated by the fact that some patients have undiagnosed diabetes. Undiagnosed diabetes represents almost one third of all diabetes cases in the general population of the United States, impacting approximately 8.1 million individuals [9]. Estimates of undiagnosed diabetes among hospitalized patients vary widely, but are higher than 20% in some settings [10–13].

A prior study of hospitalized Black and White patients in Georgia found that patients with previously undiagnosed hyperglycemia had higher rates of in-hospital morality (16%) than those with either previously diagnosed diabetes (3%) or normoglycemia (1.7%) [14]. Poor outcomes from in-hospital hyperglycemia have also been seen in other studies [15]. While admissions for hyperglycemia are currently declining, rates among some populations, including black Medicare beneficiaries, remain high [16].

The prevalence of hyperglycemia and undiagnosed diabetes among hospitalized Native Hawaiian and Asian American populations has not been adequately studied. However, high rates of undiagnosed diabetes have been found among Native Hawaiians and Asian

Americans in the general population and in outpatient setting in addition to high rates of diagnosed diabetes [2,17,18]. This suggests that undiagnosed diabetes may also be high for hospitalized patients from these populations. As in-hospital hyperglycemia is associated with poor clinical outcomes and mortality both for those with and without a previous diagnosis of diabetes [14,15], this suggests that higher rates of undiagnosed diabetes among Asians, Native Hawaiians, and other Pacific Islanders might result in worse outcomes for these groups.

Capitalizing on opportunities for screening and early diagnosis is of vital importance. The hospital is a convenient setting for early screening and diagnosis. As type 2 diabetes is usually asymptomatic early in its course, chronic complications are already present in many patients newly diagnosed with the disease, suggesting that the actual onset of the disease precedes the diagnosis by many years [19–20]. It is thus important to consider those who may be undiagnosed at a point of contact in the health care system as a potential opportunity to intervene earlier to reduce preventable complications or morbidity.

The study goals were: (1) to determine the burden of diabetes (both undiagnosed and diagnosed) among Native Hawaiian and Asian hospitalized patients, who are known to be at increased risk of diabetes, and (2) to consider the consequences of diabetes status in terms of readmissions over the 2-year study period. Hospitalizations account for nearly one-third of all health care expenses for the US's non-institutionalized population and a considerable amount of the national diabetes burden [21]. Multiple hospitalizations are very common among those with diabetes [22]. They may be even more common among those with undiagnosed diabetes as these individuals may not be aware of the health impact of diabetes on their overall health status.

The specific racial/ethnic groups studied were Native Hawaiians, Whites, Filipinos, Chinese, Japanese and other Asian American or Pacific Islanders (AA/PI). We hypothesized that there would be differences across Native Hawaiian and Asian American subgroups in the prevalence of both diagnosed and potentially undiagnosed diabetes. Specifically, we expected that Native Hawaiians and Filipinos would have higher rates of both diagnosed and potentially undiagnosed diabetes compared to Whites even in multivariable adjusted models. We also hypothesized that those with potentially undiagnosed diabetes would have more readmissions during the study period than groups with both known diabetes and without diabetes.

2. Subjects

2. 1 Data Source

Hawai'i is one of four states in the US with a 'majority minority' population, and the state with the largest proportion of Asians and Native Hawaiians. Over 30% of the population is Asian and at least 25% are Native Hawaiian or other Pacific Islander [23, 24].

2. 2 Hawai'i Health Information Corporation Data (HHIC)

HHIC collects detailed inpatient discharge data at the patient level from all hospitalizations by all payers in the state. HHIC inpatient data includes information on race/ethnicity of

patients, insurer, age, gender, and International Classification of Diseases – 9th revision – Clinical Modification (ICD-9) codes [25]. Long-term care and psychiatric hospitals are excluded. This data is cleaned by HHIC and is used as the Hawai'i hospital data source for the major national inpatient data-base [25].

2. 3 The Queen's Medical Center

The Queen's Medical Center (QMC) is a 500-bed, urban, university-affiliated hospital that is the largest tertiary care referral center in the Pacific Basin.

2. 4 Study Population

We included all acute medical and surgical discharges from hospitalized patients between 1/1/2007 to 12/31/2008 at QMC. Pregnancy-related hospitalizations were excluded. We merged Hemoglobin A1c (HbA1c) and plasma glucose laboratory data from QMC patients with HHIC inpatient data for individuals hospitalized at QMC during the study years. This created a sample of non-pregnancy-related hospitalizations by any individual aged 18+ at QMC between 1/1/2007 to 12/31/2008. A total 35,321 hospitalizations were identified in this way. Hospitalizations were excluded if they did not report race/ethnicity (n=191) or island of residence (n=16). This left 35,114 hospitalizations for 24,854 unique patients. A study sample flow diagram can be seen as Figure 1.

3. Methods

3. 1 Diabetes Diagnoses

Discharge ICD-9 codes in the HHIC data identified hospitalizations for diabetes, either uncomplicated diabetes (250.00) or diabetes complications (250.02- 250.93).

3. 2 Lab Values

Labs for this study were obtained retrospectively from data collected during usual care at the hospital. The HbA1c test is not part of the routine panel. We thus have HbA1c lab values only for the 5.67% (1010/17,828) of patients who had this test ordered as part of usual care.

3. 3 Potentially Undiagnosed Diabetes

Potentially undiagnosed diabetes was defined as HbA1c (≥6.5%) or glucose (≥200 mg/dl). HbA1c values reflect mean glucose levels over the preceding three months and have particular value as a diagnostic tool in the hospital setting as it is relatively unaffected by acute elevations in glucose levels (stress hyperglycemia) associated with severe illness [26–27]. However, as only a few individuals with undiagnosed diabetes are likely to have a HbA1c lab value taken in the course of their hospitalization as described above, we also identified potentially undiagnosed diabetes using random plasma glucose (RPG). Those with the first RPG during the visit or the last RPG ≥200 mg/dl were also considered to have potentially undiagnosed diabetes [28].

3. 4 Missing Lab Values

Approximately 28% of hospitalizations from individuals that did not have diagnosed diabetes in the HHIC data were missing lab data. As we could not estimate potentially undiagnosed diabetes for these individuals, these cases were excluded (n =10,124). Thus our final analysis sample was 24,990 hospitalizations for 17,828 patients.

3. 5 Multiple Hospitalizations

Among those who did not expire on index admission (n=17,164), we considered the total number of additional visits (beyond the index admission) during the study period for each individual by glucose status (i.e., diagnosed diabetes, potentially undiagnosed diabetes, or no diabetes). Multiple visits were dichotomized into a binary variable: yes (>1 hospitalization) vs. no (only index hospitalization).

3. 6 Race/Ethnicity

The HHIC race/ethnicity variable is created from self-reported race/ethnicity categories available consistently across all hospitals in Hawai‘i during the study period. Only one primary race/ethnicity is reported. Mixed-race individuals are represented as their primary self-reported race/ethnicity.

3. 7 Other Variables

For multivariable models, we considered Sex (male/female based on administrative data), Age (categorized into 4 groups: 18–39, 40–64, 65–84, 85+ years), Payer (Medicare, Medicaid, Private, and Other) and location of residence (lives on Oahu or on another neighbor island in the state of Hawai‘i) as these factors are associated with diabetes status [29]. We also compared length of stay (LOS) and mortality during the hospital stay by diabetes status by race/ethnicity.

3. 8 Statistical Methods

Descriptive statistics were used to summarize patient characteristics. Patient and hospital visit characteristics by those with diagnosed diabetes, potentially undiagnosed diabetes, and no diabetes was compared using Chi-square test for categorical variables and Kruskal-Wallis test for continuous variables. Multivariable log-binomial models predicted diabetes (both diagnosed and potentially undiagnosed) controlling for race/ethnicity, age, residence, gender, and payer. Multivariable log-binomial models also predicted multiple visits during the study period (among those that did not die on index admission). All analyses were performed in SAS 9.3 (SAS Institute Inc.) and $p<0.05$ was considered statistically significant.

3.9 Human Subjects

This study was reviewed and approved by the University of Hawai‘i Institutional Review Board (IRB) and the Queens Medical Center IRB.

4. Results

Of 24,990 hospitalizations for 17,828 patients meeting study criteria, 3.4% included potentially undiagnosed diabetes and 30.5% included diagnosed diabetes. Among those with undiagnosed diabetes patients (n=603), 25.4% patients had undiagnosed diabetes by HbA1c vs. 74.6% by RPG.

As seen in Figure 2, the prevalence of total diabetes (diagnosed and potentially undiagnosed) among hospitalized patients varied significantly for Native Hawaiian and Asian American subgroups compared to Whites. (Ninety-five percent confidence intervals for prevalence estimates in Figure 2 and for the study overall can be found in Appendix A.) Of note, the main variation across racial/ethnic groups was in diagnosed diabetes. While 19% of hospitalizations among Whites included a diabetes diagnoses, the prevalence of diagnosed diabetes was 32% for Chinese, 33% for Filipinos, 34% for Japanese, and 38% for Native Hawaiians ($p<.0001$). Between 2–4% of all racial/ethnic groups had potentially undiagnosed diabetes.

Table 1 provides more demographic detail concerning those hospitalized with diabetes (diagnosed and potentially undiagnosed) as well as those with normal glucose. Variation across diabetes type was also seen in age group ($p<.0001$), payer mix ($p<.0001$), location of residence ($p<.0001$), but not in gender ($p=0.29$). Of interest, those hospitalized with diagnosed or potentially undiagnosed diabetes were, on average, four years older than those hospitalized without diabetes ($p<.0001$). Also, a higher percentage of those with diagnosed diabetes had public payers (Medicaid or Medicare) compared to those with potentially undiagnosed diabetes or no diabetes. Specifically, 69.1% (2,683/5,444) of those with diagnosed diabetes had a public payer, compared to 59% (356/603) of those with potentially undiagnosed diabetes, and 58.2% of those with no diabetes (6,855/11,781). Higher percentages of those from Oahu were seen among those with diagnosed diabetes (87.5%; 189/5,444) compared to those with potentially undiagnosed diabetes (80.8%; 487/603) or no diabetes (79.6%;9,383/11,781) ($p<.0001$). Those with potentially undiagnosed diabetes were significantly more likely to die within the index admission (9.3%;56/603) compared to those with diagnosed diabetes (3.5%;189/5,444) or no diabetes (3.6%;419/11,781) ($p<.0001$).

In multivariable models controlling for age, gender, insurance, and place of residence (Table 2), Native Hawaiian and all Asian groups had significantly higher rates of diagnosed diabetes than Whites (Native Hawaiian:RR:1.95;95%CI:1.81–2.10; Chinese:RR:1.49; 95%CI:1.35–1.65; Filipino:RR:1.67;95%CI:1.54–1.82; Japanese:RR:1.60;95%CI:1.49–1.73). Those in the two middle age groups were more likely to have diagnosed diabetes than those in the oldest age group (85+) after adjustment, while those in the youngest age groups were significantly less likely. Those with public insurance, both Medicaid and Medicare, were significantly more likely to have diagnosed diabetes compared to those with private insurance. In multivariable models predicting potentially undiagnosed diabetes, only older age was a significant predictor. No other variables were significantly associated with potentially undiagnosed diabetes in multivariable models, including race/ethnicity.

Figure 3 shows the impact of diabetes status on multiple hospitalizations during the study period by individuals within race/ethnicity for those who did not expire during the index hospitalization. In all racial/ethnic groups, those with potentially undiagnosed diabetes were more likely to be readmitted during the study period than both those with diagnosed diabetes and those without diabetes. Those with diagnosed diabetes consistently had more hospitalizations than individuals without diabetes across racial/ethnic groups.

Table 3 shows the adjusted models for this outcome. Potentially undiagnosed diabetes was associated with significantly more hospitalizations during the study period than for those with no diabetes and those with diagnosed diabetes. Those with diagnosed diabetes had significantly more hospitalizations during the study period compared to those with no diabetes. Other factors predicting having more hospitalizations during the study period were older age, living on Oahu and having public (vs. private) health insurance.

Table 4 shows the differences in LOS and death during hospitalization by diabetes type specifically for each racial/ethnic group. In all racial/ethnic groups, those with undiagnosed diabetes had the longest length of stay and were more likely to die during the hospitalization. Within racial/ethnic groups, the differences in length of stay and mortality, separately, by diabetes type were statistically significant ($p<0.05$) for Chinese, Filipino, Japanese, and White patients, but not for Native Hawaiian, other Asian/Pacific Islander, or other race/ethnicity. Interestingly, within diabetes types, no significant differences were seen by race/ethnicity for LOS, though significant differences were seen for mortality. For all three diabetes types, Chinese and Japanese were most likely to die during hospitalization.

5. Discussion

In the US generally, approximately 16–25% of hospitalized patients have diagnosed diabetes [5, 6]. Our study found considerably higher rates of diabetes among hospitalized patients; 30.5% had a known diagnosis. As hypothesized, the unadjusted diabetes prevalence was high for Native Hawaiians and Filipinos as well as for other Asian subgroups. While 19% of hospitalizations among Whites included a diabetes diagnosis, the prevalence was considerably higher in all other non-White racial/ethnic groups (32% for Chinese, 33% for Filipinos, 34% for Japanese, and 38% for Native Hawaiians).

Native Hawaiians and all Asian subgroups had similar rates of potentially undiagnosed diabetes. In all racial/ethnic groups, between 2–4% had potentially undiagnosed diabetes. This is consistent with the percentages of undiagnosed diabetes reported in some other research, but lower than other reports [10–13]. For example, a recent study that examined HbA1c levels found that 18% of hospitalized patients had undiagnosed diabetes [10]. Similarly, Umpierrez et al examined 2,030 hospitalized patients, over 50% of whom were Black, and found that 26% had a history of diabetes and that 12% had hyperglycemia without a diagnosis of diabetes [14]. Measuring potentially undiagnosed diabetes is a challenge, particularly retrospectively, which likely (along with clinical and demographic differences across studied patient populations) helps explains the wide range of prevalence rates across previous studies. Additionally, glucose-based measures alone, the primary

measure in our study, have been shown to underestimate undiagnosed diabetes prevalence [30].

Primarily due to the higher prevalence of diagnosed diabetes in hospitalized patients, the overall burden of diabetes (both undiagnosed and diagnosed) is high for Native Hawaiian and Asian subgroups. Hospitalized Native Hawaiians have a particularly high total burden of diabetes (both diagnosed and undiagnosed) (41%) compared to Whites (23%).

The high prevalence of diabetes among hospitalized Japanese, Chinese, Native Hawaiians, and Filipinos compared to Whites is a new finding and should be useful to public health care providers, health planners, hospital administrators especially those who may be interested in early detection and/or reducing health care costs. Clinically-oriented researchers considering health disparities may also be interested in these findings as they seek to better understand the underpinnings of racial/ethnic differences in hospitalized patients.

Our results also indicate that potentially unrecognized diabetes may also impact health care outcomes. The increased rehospitalization rate for those with potentially undiagnosed diabetes is consistent with other studies that reported poorer clinical outcomes, including higher mortality rates, in this group compared with those with and without diagnosed diabetes [14, 15]. If this is due to unrecognized diabetes, then patients who have undiagnosed diabetes may appear to be healthier than they actually are (i.e., they are not aware of a major chronic disease) and would be unlikely to care for their chronic disease.

Health care quality reporting presents a particular incentive for hospitals and providers, particularly those who care for large numbers of patients with potentially undiagnosed diabetes, to identify these cases. Otherwise, patients with undiagnosed diabetes would have none of their particular diabetes-related risk in their charts or discharge information. Thus, this information could not be included in risk adjustment models that might help explain poor facility- or provider-related outcomes due to higher rates of diabetes in patient population. This may lead to lower scores on “report cards” for performance than would be the case if true patient risk was reflected and risk adjusted. Our finding that undiagnosed diabetes patients have more adverse health outcomes is strongly supported in the literature. Providers and patients unaware of existing diabetes or early manifestation of diabetes are unlikely to treat hyperglycemia leaving these patients more likely to experience adverse outcomes and/or complications, especially under hospitalization with increased stress on glucose homeostasis [10,14,27].

Those with potentially undiagnosed diabetes in this study may have more hospitalizations for other reasons than undiagnosed diabetes. They may be much sicker overall and/or they may have been hospitalized for distinct reasons, such a trauma or chemotherapy, for which testing for diabetes (or even coding for known diabetes) might not be a priority. The fact that those hospitalized for potentially undiagnosed diabetes in this study had higher rates of death during the index hospitalizations supports the idea that this group may have a high severity of illness related to conditions that were not examined in this study. Furthermore, undiagnosed diabetes may also be a marker of poor access to care.

Hospitalized patients present a unique opportunity for diabetes screening and potential cost savings. The adverse clinical outcomes following hospitalization suggest that more aggressive treatment of hyperglycemia (>200 mg/dl) is warranted. Screening with HbA1c criteria to identify those in need may be particularly useful as glucose criteria may result in over-diagnosis. Such efforts should be evaluated prospectively to determine if they can improve outcomes.

Given the already high prevalence of diagnosed diabetes among ethnic minorities in the state of Hawai‘i [2], screening of high-risk patients in the hospital setting may reduce diabetes-related morbidity as well as lower costs associated with future hospitalizations from diabetes-related complications. However, identifying hyperglycemia in the hospital without a definitive diagnosis of diabetes is also controversial, especially given the adverse affects of hypoglycemia that may result with overly aggressive glucose management [16]. Referring patients to outpatient primary care providers to ascertain diabetes status following hospitalization may also be useful, particularly since the diagnostic criteria for diabetes requires that patients not be under medical or physical stress.

Future work is needed to better understand the individuals identified as having potentially undiagnosed diabetes in our study. Was their diabetes ‘missed’ completely in the hospital setting? Was a diabetes diagnosis in the patient chart not included in the clinical coding for some reason? Do those hospitalized with “undiagnosed” diabetes have distinct reasons for hospitalizations, such as trauma? If so, how many of those with potentially undiagnosed diabetes could actually benefit from hospital-based screening and does this vary by race/ethnicity?

The treatment of in-hospital hyperglycemia could potentially reduce the high morbidity and mortality burden of this condition, though this is understudied [14, 15]. Recent trends suggest that, indeed, practice-based factors are having an impact in reducing not only the rates of in-hospital hyperglycemia, but also the poor outcomes associated with this condition [16]. However, admissions that include hypoglycemia, a potential adverse consequence of glycemic-control treatment, are now higher than admissions including hypoglycemia and are associated with even poorer clinical outcomes [16]. Such issues should be considered in clinical care management plans.

This study may have important policy implications, in large part because of the heavy burden on the overall health care system for hospitalized patients with diabetes. We considered payer status and found that, even in multivariable models, those with public insurance were more likely to have diagnosed diabetes and multiple visits. Thus, this is an important health policy issue.

Previous studies on diabetes prevalence among hospitalized patients were not conducted in populations that included significant portions of Native Hawaiian, Pacific Islander, or Asian American populations. Yet this study shows stark differences by racial/ethnic groups in terms of prevalence of diabetes in hospitalized patients with likely consequences on both cost and outcomes. Decreasing diabetes in these communities is a critical step for reducing cost and improving outcomes. Our results suggest that more attention to cost-effective

chronic disease management generally, and diabetes management specifically, in these high-risk racial/ethnic groups is urgently needed [2, 18, 31]. These interventions should integrate "best clinical practices," address feasibility and out-of-pocket costs, and be culturally relevant and practical to these diverse populations [2, 18, 31].

Of all five non-white populations included in this study, Native Hawaiians showed the most extreme diabetes disparities with a total of 41% of all Native Hawaiian admission including a diabetes diagnosis compared with national rates of only 20% of all hospitalizations including a diabetes diagnosis designation. This suggests that the impact of glycemic control before, during and after hospitalization may directly impact patient outcomes and represents a modifiable factor in improving health outcomes and reducing health care costs.

This study has a number of strengths, including representation of diverse Asian American and Pacific Islander groups. Combining these heterogeneous groups masks differences in prevalence of disease and access to care, limiting our ability to tailor interventions for maximum effectiveness to reverse these disparities [2,18, 32]. Yet most population-based studies on this topic lack the sample sizes to disaggregate these groups.

However, the study has some limitations. We did not test lab values prospectively. Instead, we were only able to determine hospitalizations for potentially undiagnosed diabetes for individuals with lab records. We may thus underreport undiagnosed diabetes. Comparing those with and without lab data (Appendix B), those lacking lab data were more likely to be female, older, live on Oahu and have Medicare. As advanced age is associated with diabetes generally and potentially undiagnosed diabetes in our study, we may be underestimating potentially undiagnosed diabetes. On the other hand, our glucose-based criteria for undiagnosed diabetes may be particularly subject to biases in the direction of overestimating potentially undiagnosed diabetes. High RPG can be a marker of 'sickness" or stress, rather than diabetes specifically, or could be due to use of steroids, the receipt of fluids containing dextrose, or many other causes [33]. In these cases, study methods may overestimate undiagnosed diabetes. Also, our undiagnosed diabetes guidelines are similar, though not identical, to published guidelines indicating diabetes to be >200 mg/dl specifically with hyperglycemic symptoms or crisis [34]. These additional criteria were not included in our study. Thus, our method of finding "potentially undiagnosed diabetes" has a low a priori sensitivity, and we were not able to do follow-up to document the validity of the diagnosis. Given the limitations in systematic testing, test sensitivity, and validation in follow-up, an important area for future research would be to determine if our prevalence numbers are an under- or over-estimate of undiagnosed diabetes in these populations. This issue may help explain why we did not find as many people with undiagnosed diabetes using the current methods as have been found in previous studies [10–13]. Prospective studies on this topic that address these limitations would be useful.

We lack data regarding patients' pathways to hospitalizations. It is possible that some groups are disproportionately going to the hospital when their status is more acute while others are presenting for more primary care. As this study also lacks lab detail for those with diagnosed diabetes, we cannot compare the HbA1c or glucose levels of those with diabetes by race/ethnicity to better understand this acuity issue or to assess the validity of the ICD-9

based “diabetes” determination. Thus, we cannot fully understand the differences in the admission of patients with known diabetes who had distinct ethnic characteristics. Interestingly, our analysis of LOS and mortality indicate that differences are seen across several studied racial/ethnic groups for visits within diabetes types, yet Native Hawaiians of all types look very similar across LOS and mortality. As seen in other racial/ethnic minority group [35] there may be variability in HbA1c and glucose due to non-modifiable factors in Native Hawaiians and other studied groups that may affect the diagnostic cut off levels [36]. These may all be fruitful areas for future research.

Other limitations have to do with the constraints of administrative data. Because ICD-9 discharge coding is for reimbursement, it is possible these would not always include diagnosed diabetes that appeared in the hospital chart and was used in clinical decision-making or patient management. Patients may have a diagnosis of diabetes, but not have this ICD-9 code on their discharge data. However, this limitation is also a relevant research issue as diabetes is a significant co-morbidity that is important to capture in discharge data for analyses purposes, including severity adjustment.

Race/ethnicity was from hospital data and racial/ethnic identification may have varied slightly across hospitals. In 2010, the HHIC implemented new methods to standardize race/ethnicity reporting across all Hawaii hospitals, and future work can considered differences in findings using the new racial/ethnic categorizations. Also, administrative data does not contain information on many factors that might be useful to explain or better understand disparities, particularly clinical factors and social determinants [37]. These are important areas for further study. Also, our model of multiple visits did not control for severity of illness or other acute or chronic conditions. Finally, our findings are only from one acute care hospital in one location. Results in other settings may vary.

5. 1 Conclusions

This study addressed a gap in our understanding of racial and ethnic differences in diabetes in multiple, high-risk populations of Native Hawaiian and Asian American hospitalized patients. Native Hawaiians and all studied Asian groups had significantly higher percentages of diagnosed diabetes compared to Whites, though they did not differ significantly in terms of prevalence of potentially undiagnosed diabetes. Hospitalized Native Hawaiians have a particularly high total burden of diabetes (both diagnosed and potentially undiagnosed) (41%) compared to Whites (23%). Attention to cost-effective chronic disease management generally, and diabetes management specifically, in these high-risk racial/ethnic groups is urgently needed.

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Highlights

- Diagnosed diabetes for hospitalized patients was: Native Hawaiian (38%), Japanese (34%), Filipino (33%), Chinese (32%), and Whites (19%).
- Potentially undiagnosed diabetes for hospitalized patients was: Native Hawaiian (3%), Japanese (3%), Filipino (4%), Chinese (4%), and Whites (4%).
- Few potentially undiagnosed diabetes cases were found. Prospective methods are recommended.
- Potentially undiagnosed diabetes was associated with a longer hospital stay and higher mortality.
- Diabetes screening in hospitalized patients using hemoglobin A1c is suggested and should be evaluated prospectively for outcome improvements.

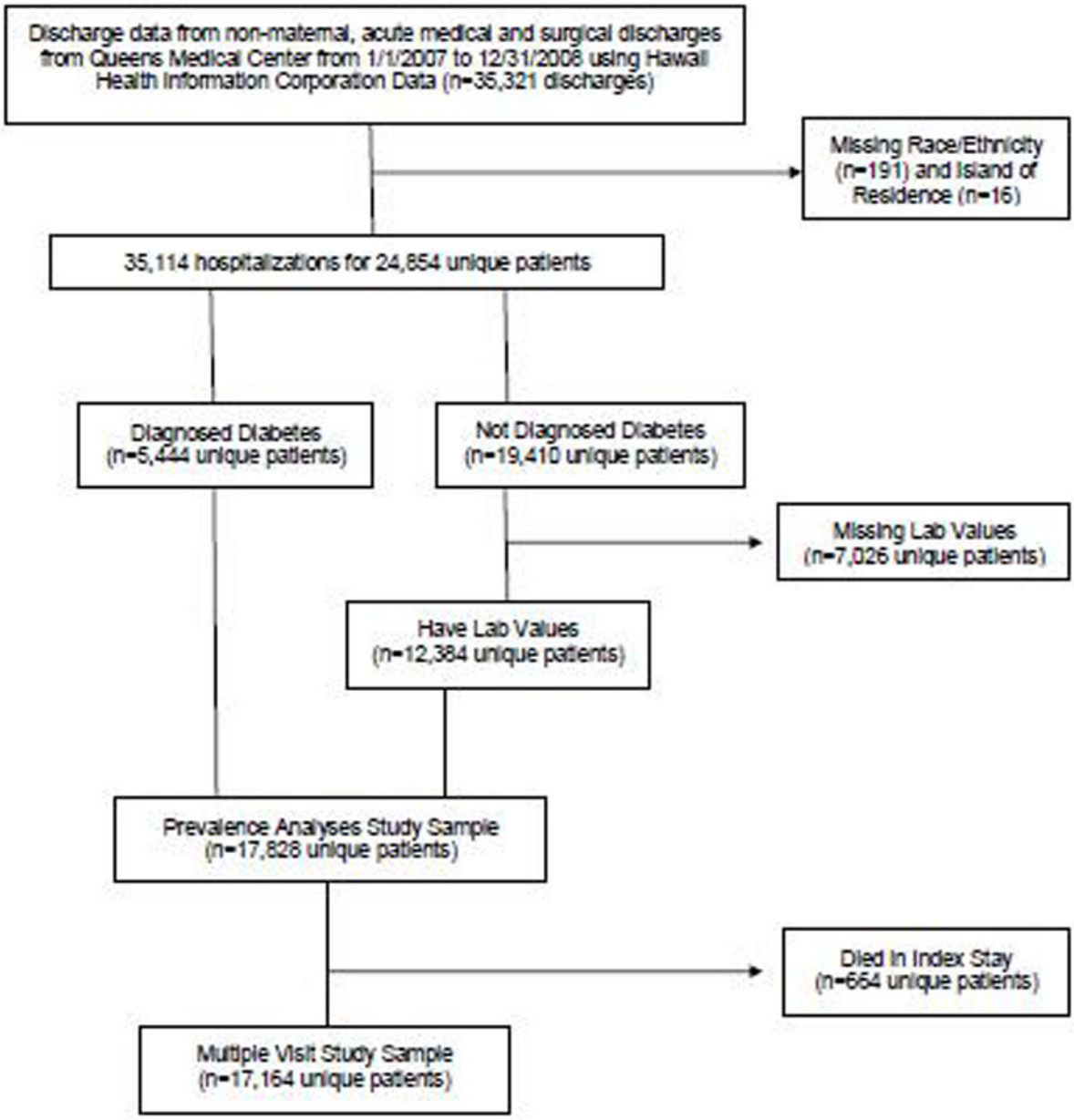

Figure 1.
Study Sample Flow Chart

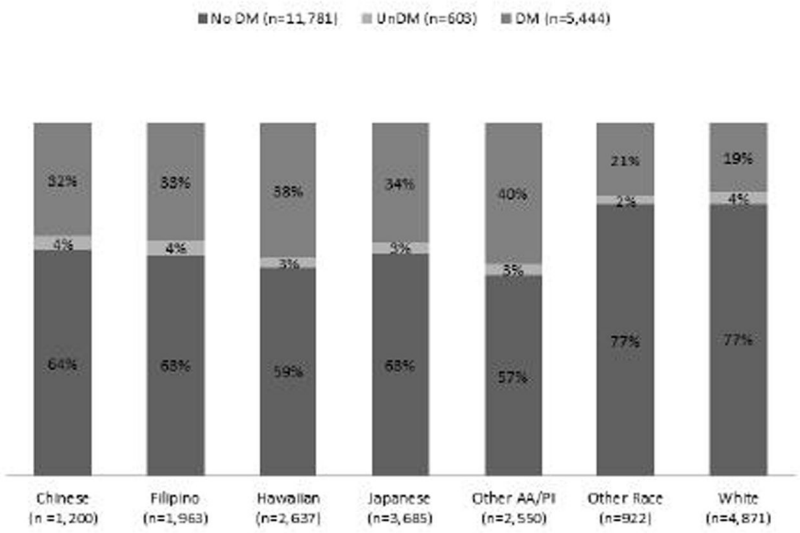

Figure 2.

Total diabetes burden by race/ethnicity (n=17,828) for individuals with diagnosed diabetes (DM), potentially undiagnosed diabetes (UnDM), and no diabetes[1]

[1]Among those who either had diagnosed diabetes in the administrative data or lab values.

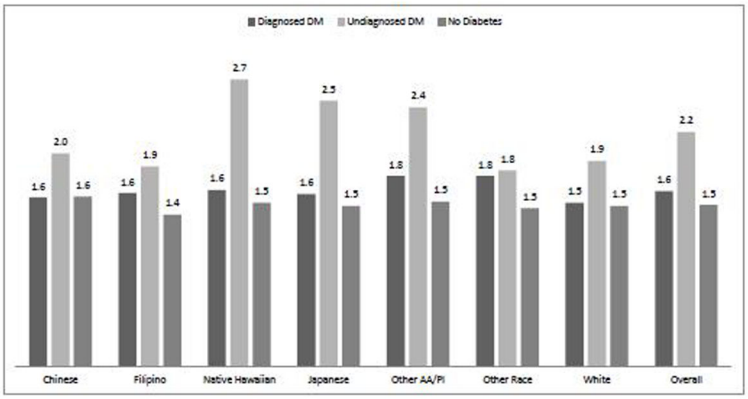

Figure 3.

Average number of visits during study period by race/ethnicity by diabetes burden[2],[3]

[2]Among those who either had diagnosed diabetes in the administrative data or lab values, and also who did not expire on index admission.

[3]The average number of visits by diabetes status by race/ethnicity were compared using a non-parametric Kruskal-Wallis test. Results were as follows: Diagnosed DM (p=.01), Undiagnosed DM (p.37), and No DM (p=.02). (Lack of significance for undiagnosed diabetes despite clear variation is likely due to low power from the small number of individuals in this comparison group.)

Table 1

Description of individuals with diagnosed diabetes (DM), potentially undiagnosed diabetes (UnDM), and no diabetes among Asian American and Pacific Islander subgroup and Whites from January 2007 – December 2008[4]

Demographics	**DM**	**UnDM**	**No DM**	
Number of individuals	5,444	603	11,781	17,828
	N (%)	**N (%)**	**N (%)**	**P-value**
Ethnicity				<.0001
Chinese	386 (7.1%)	47 (7.8%)	767 (6.5%)	
Filipino	657 (12.1%)	76 (12.6%)	1,230 (10.4%)	
Japanese	1,248 (22.9%)	119 (19.7%)	2,318 (19.7%)	
Other AA/PI	1,017 (18.7%)	89 (14.8%)	1,444 (12.3%)	
Native Hawaiian	1,006 (18.5%)	75 (12.4%)	1,556 (13.2%)	
Other Race	190 (3.5%)	23 (3.8%)	709 (6.0%)	
White	940 (17.3%)	174 (28.9%)	3,757 (31.9%)	
Gender				
Female	2,512 (46.1%)	272 (45.1%)	5,286 (44.9%)	0.2946
Age Group				<.0001
18–39	296 (5.4%)	48 (8.0%)	1,886 (16.0%)	
40–64	2,387 (43.8%)	255 (42.3%)	4,756 (40.4%)	
65–84	2,335 (42.9%)	225 (37.3%)	3,876 (32.9%)	
85+	426 (7.8%)	75 (12.4%)	1,263 (10.7%)	
Payer				
Medicaid/Quest	885 (16.3%)	72 (11.9%)	1,732 (14.7%)	<.0001
Medicare	2,873 (52.8%)	284 (47.1%)	5,123 (43.5%)	
Private Insurance	1,418 (26.0%)	187 (31.0%)	3,744 (31.8%)	
Other Insurance	268 (4.9%)	60 (10.0%)	1,182 (10.0%)	
Live on Oahu				
Yes	4,766 (87.5%)	487 (80.8%)	9,383 (79.6%)	<.0001
Expired on Index Admission				
Yes	189 (3.5%)	56 (9.3%)	419 (3.6%)	<.0001
	Mean ±SD	Mean ±SD	Mean ±SD	
Age (years)	64.3 ± 14.7	64.0 ± 16.9	60.3 ± 19.2	<.0001
Average hospitalizations (for those who did not expire during index admission)	1.6 ± 1. 4	2.2 ± 1.9	1.5 ± 1.2	<.0001

[4]Descriptive statistics, frequency and percentage for categorical variables and means and standard deviations for continuous variable are based on individual first visit unless otherwise indicated.

Table 2

Predictors of diabetes (diagnosed and undiagnosed) from multivariable log-binomial models based on patient-level data (n=17,828)[1]

	Diagnosed Diabetes	Undiagnosed Diabetes
	RR[95%CI]	**RR[95%CI]**
Race/Ethnicity		
Chinese vs. White	**1.49 [1.35, 1.65]**	1.07 [0.77, 1.47]
Filipino vs. White	**1.67 [1.54, 1.82]**	1.11 [0.85, 1.44]
Hawaiian vs. White	**1.95 [1.81, 2.10]**	0.85 [0.65, 1.12]
Japanese vs. White	**1.60 [1.49, 1.73]**	0.87 [0.69, 1.10]
Other AA/PI vs. White	**2.02 [1.88, 2.18]**	1.07 [0.82, 1.38]
Other vs. White	1.13 [0.99, 1.30]	0.76 [0.50, 1.18]
Gender		
Female vs. Male	0.98 [0.94, 1.02]	0.99 [0.85, 1.16]
Age		
18–39 vs. 85+	**0.66 [0.57, 0.76]**	**0.41 [0.27, 0.63]**
40–64 vs. 85+	**1.57 [1.42, 1.74]**	**0.69 [0.50, 0.95]**
65–84 vs. 85+	**1.53 [1.40, 1.67]**	0.80 [0.61, 1.03]
Payer		
Medicaid vs. Private	**1.19 [1.12, 1.28]**	0.82 [0.62, 1.08]
Medicare vs. Private	**1.28 [1.19, 1.37]**	0.81 [0.63, 1.04]
Other vs. Private	**0.78 [0.70, 0.88]**	1.26 [0.94, 1.68]
Island		
Live in Oahu vs. not	1.02 [0.98, 1.07]	1.01 [0.86, 1.18]

[1]Race/ethnicity, gender, age, payer, and island information was based on first visit.

Table 3

Predictors of Multiple Visits during the Study Period among those who did not expire at index admission[1]

	Multiple visit
	RR (95%CI)
Diabetes Status	
Undiagnosed DM vs. No DM	**1.44 [1.31, 1.60]**
Diagnosed DM vs. No DM	**1.09 [1.04, 1.15]**
Undiag nosed DM vs. Diagnosed DM	**1.32 [1.19, 1.46]**
Race/Ethnicity	
Chinese vs. White	0.98 [0.89, 1.08]
Filipino vs. White	0.85 [0.78, 0.93]
Hawaiian vs. White	1.02 [0.94, 1.09]
Japanese vs. White	0.94 [0.88, 1.01]
Other AA/PI vs. White	1.00 [0.92, 1.07]
Other vs. White	0.97 [0.87, 1.09]
Sex	
Female vs. Male	0.95 [0.91, 1.01]
Age	
18–39 vs. 85+	**0.81 [0.72, 0.92]**
40–64 vs. 85+	**0.90 [0.82, 0.99]**
65–84 vs. 85+	**0.85 [0.79, 0.91]**
Payer	
Medicaid vs. private	**1.26 [1.17, 1.36]**
Medicare vs. private	**1.27 [1.17, 1.37]**
Other vs. private	**0.50 [0.44, 0.58]**
Live in Oahu	
Yes vs. no	**1.98 [1.81, 2.16]**

[1]The multivariable model for multiple visits was based on patient-level data. The information for ethnicity, sex, age, payer and Island were according to first visit. Model: Multiple visit = Diabetes Status + Ethnicity + sex + age group + payer +live in Oahu.

Table 4

Length of Stay (LOS) and mortality of individuals among Asian American and Pacific Islander subgroups and Whites overall and by diagnosed diabetes (DM), potentially undiagnosed diabetes (UnDM), and no diabetes from January 2007 – December 2008

	Chinese	Filipino	Native Hawaiian	Japanese	Other AA/PI	Other Race	White	p-value
Diagnosed DM								
LOS, Mean ± SD	7.7 ± 14.1	7.8 ± 16.8	8.8 ± 17.4	7.6 ± 11.3	8.4 ± 13.7	9.9 ± 17.2	7.4 ± 11.9	0.085
Mortality (during stay), n (%)	37 (9.6%)	43 (6.5%)	53 (5.3%)	106 (8.5%)	63 (6.2%)	10 (5.3%)	49 (5.2%)	0.004
Undiagnosed DM								
LOS, Mean ± SD	10.6 ±14.1	11.9 ±18.8	8.9 ± 8.5	9.8 ± 12.9	11.5 ± 22.3	11.4 ±17.8	13.3 ± 46.9	0.70
Mortality (during stay), n (%)	13 (27.7%)	13 (17.1%)	1	32 (26.9%)	1	1	27 (15.5%)	0.002
No DM								
LOS, Mean ± SD	7.5 ± 11.7	7.4 ± 11.4	7.9 ± 16.2	7.9 ± 12.1	7.1 ± 9.7	8.7 ± 22.4	8.2 ± 17.7	0.21
Mortality (during stay), n (%)	75 (9.8%)	68 (5.5%)	73 (4.7%)	193 (8.3%)	85 (5.9%)	23 (3.2%)	202 (5.4%)	<.0001
Comparison by DM status within race/ethnicity								
p-values for LOS	0.041	<.0001	0.095	0.0009	0.50	0.13	<.0001	
p-values for mortality	0.0004	0.0003	0.18	<.0001	0.49	0.20	<.0001	

[a]Number was analyzed, but is too small to be publically reported due to data privacy rules, which require numbers under 10 to be suppressed to protect patient confidentiality.

[b]Number was analyzed, but is too small to be publically reported due to data privacy rules, which require numbers under 10 to be suppressed to protect patient confidentiality.

[c]Number was analyzed, but is too small to be publically reported due to data privacy rules, which require numbers under 10 to be suppressed to protect patient confidentiality.

Appendix A

Confidence interval for proportion estimates for diabetes burden by race/ethnicity estimates in Figure 2 for individuals with diagnosed diabetes (DM), potentially undiagnosed diabetes (UnDM), and no diabetes (noDM).[1]

	# of No DM/DM/ UnDM	% of No DM	95% CI of % for No DM[2]	% of UnDM	95% CI of % for UnDM[2]	% of DM	95% CI of % for DM[2]
Ethnicity							
Chinese	1,200	63.9%	61.2–66.7%	3.9%	2.9–5.2%	32.2%	29.4–34.7%
Filipino	1,963	62.7%	60.5–64.8%	3.9%	3.1–4.9%	33.5%	31.4–35.6%
Hawaiian	2,637	59.0%	57.1–60.9%	2.8%	2.2–3.5%	38.2%	36.3–40.1%
Japanese	3,685	62.9%	61.3–64.5%	3.2%	2.7–3.8%	33.9%	32.4–35.5%
Other AA/PI	2,550	56.6%	54.7–58.5%	3.5%	2.8–4.3%	39.9%	38.0–41.8%
Other Race	922	76.9%	74.0–79.6%	2.5%	1.6–3.7%	20.6%	18.0–23.4%
White	4,871	77.1%	75.9–78.3%	3.6%	3.1–4.2%	19.3%	18.2–20.4%
Total	17,828	66.1%	65.4–66.8%	3.4%	3.1–3.7%	30.5%	29.8–31.2%

[1]Among those who either had diagnosed diabetes in the administrative data or lab values

[2]Two-sided 95% confidence interval
[2]Two-sided 95% confidence interval
[2]Two-sided 95% confidence interval

Appendix B

Comparison of Analysis Sample and those Missing Lab Values

	Have Lab Values	DM unknown	p-value
Number of individuals	17,828	7,026	
Ethnicity			<.0001
Chinese	1,208 (6.8%)	382 (5.4%)	0.0001
Filipino	1,964 (11.0%)	637 (9.1%)	<.0001
Hawaiian	2,637 (14.8%)	978 (13.9%)	0.0665
Japanese	3,680 (20.7%)	1,123 (16.0%)	<.0001
Other AA/PI	2,539 (14.2%)	860 (12.2%)	<.0001
Other Race	928 (5.2%)	545 (7.8%)	<.0001
White	4,872 (27.3%)	2,501 (35.6%)	<.0001
Gender			<.0001
Female	8,070 (45.3%)	3,478 (49.5%)	
Age Group			<.0001
18–39	2,264 (12.7%)	2,015 (28.7%)	<.0001
40–64	7,419 (41.6%)	3,216 (45.8%)	<.0001
65–84	6,414 (36.0%)	1,534 (21.8%)	<.0001
85+	1,731 (9.7%)	261 (3.7%)	<.0001
Payer			<.0001
Medicaid/Quest	2,617 (14.7%)	1,014 (14.4%)	0.4618
Medicare	8,292 (46.5%)	1,861 (26.5%)	<.0001
Private Insurance	5,322 (29.9%)	3,218 (45.8%)	<.0001
Other	1,597 (8.9%)	933 (13.3%)	<.0001
Live on Oahu	14,640 (82.1%)	5,485 (78.1%)	<.0001
Expired during index hospitalization	664 (3.4%)	118 (1.7%)	<.0001
	Mean ± SD	Mean ± SD	
Age (years)	61.5 ±18.0	51.2 ±18.7	<.0001
Average # hospitalizations (for those who did not expire on index hospitalization)	1.78 ±1.76	1.13 ±1.11	<.0001