Seroepidemiology of hepatitis B virus infection: analysis of mass screening in Hawaii

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Abstract

Background Although hepatitis B seroprevalence has been studied extensively in California and New York, detailed information for other high-risk areas in the United States is lacking. To study current prevalence and risk for hepatitis B virus (HBV) infection in Hawaii, we analyzed cross-sectional data from Hawaii residents screened between July 2003 and April 2006.

Methods We retrospectively reviewed the screening records of 3,989 participants recruited at health fairs and clinics. Prevalence and risk factors for HBV infection were estimated using univariate and multivariate logistic regression models.

Results Total prevalence of hepatitis B surface antigen (HBsAg) was 3.6%. Gender, age, and ethnicity were independently associated with HBsAg seropositivity. In a multivariate logistic regression model, males were at increased risk for HBsAg compared with females (odds

ratio [OR] = 1.53, 95% confidence interval [CI]: 1.09–2.16) and persons aged 70 years or older were less likely to test positive than those younger than 30 (OR = 0.25, 95% CI: 0.11–0.61). In addition, multivariate ORs of HBsAg seropositivity were 3.24 (95% CI: 1.04–10.09), 4.13 (95% CI: 1.66–10.29), and 7.47 (95% CI: 2.52–22.11) for Vietnamese, Chinese, and Pacific Islanders, respectively, compared with Whites.

Conclusions This study furthers current knowledge of HBV epidemiology in areas with large populations of high-risk immigrants and demonstrates the relevance of screening programs for hepatitis B.

Keywords Epidemiology · Hepatitis B · Liver disease

Abbreviations

CI	Confidence interval
HBsAg	Hepatitis B surface antigen
HBV	Hepatitis B virus
OR	Odds ratio

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Introduction

Chronic hepatitis B remains an important public health issue in the United States, as evidenced by recent recommendations to increase hepatitis B vaccination coverage among adults [1]. Approximately 1.25 million Americans are chronically infected with hepatitis B [2, 3] and are at increased risk for cirrhosis [4, 5], hepatic decompensation [6, 7], and hepatocellular carcinoma [8–10]. In a sample of the general U.S. population, the prevalence of chronic hepatitis B virus (HBV) infection was found to be 0.4% [11]. However, this prevalence value is likely an

underestimate due to underrepresentation of Asians and Pacific Islanders in the sample population. In contrast, screening programs for Asian Americans in major U.S. cities, particularly New York City and San Francisco, reported substantially higher prevalence rates ranging from 5 to 24% [12–17].

The state of Hawaii provides an ideal environment to investigate the epidemiology of hepatitis B. The population is ethnically diverse, with Asians comprising 42% of the total population and more than one-fifth of residents identifying with 2 or more races [18]. Between 2000 and 2004, Hawaii's total population increased annually by 1% due largely to a net positive international migration rate of 5,572 persons per year [19]. Of the state's 212,229 foreign-born residents surveyed in 2000, 73% were born in countries highly endemic for hepatitis B including China, Vietnam, the Philippines, and South Pacific Islands [1, 18, 20, 21]. Utilizing sera collected from a multiethnic sample of Hawaii residents in 1970, Diwan et al. [22] found overall prevalence of hepatitis B surface antigen (HBsAg) to be 2.1%.

Since the report by Diwan et al., shifting immigration patterns and adult screening programs for high-risk populations, such as prison inmates, intravenous drug users, and persons with sexually transmitted diseases [23], may have affected prevalence. Using cross-sectional data from participants of a mass screening campaign for hepatitis B in Hawaii, we examined the prevalence of HBsAg and risk factors associated with HBV infection among Hawaii residents. Because we suspected that individuals with symptoms of HBV infection would present most frequently in clinics, we also sought to determine whether Hawaii residents attending clinics had a higher likelihood of chronic HBV infection than those screened at health fairs.

Methods

Screening program

The Jade Ribbon Campaign of Hawaii is a collaborative organization of healthcare professionals and volunteers dedicated to community outreach in the areas of HBV infection and hepatocellular carcinoma. In July 2003, the Jade Ribbon Campaign of Hawaii began mass screening for HBV infection among adolescents and adults residing in Hawaii. Serological tests were provided free of charge to all interested persons. To raise awareness of this screening campaign, program directors advertised and conducted several promotional events, such as television appearances, articles in local newspapers (English and Chinese), and lectures to local physicians, urging them to test their patients for the presence of HBsAg. A total of 4,039

participants were recruited for screening at health fairs and selected clinics.

Screening was offered at 18 Hawaii health fairs that occurred between June 2004 and April 2006. Participating fairs were sponsored by a variety of institutions, including schools, a hospital, a care home, neighborhood-based organizations, and local cultural associations. Altogether, 2,261 individuals were recruited and screened at health fairs.

In addition, 1,778 individuals were screened at 46 selected private and community health clinics across Hawaii between July 2003 and December 2005. Of these clinics, 42 (91.3%) were located on the island of Oahu, where the majority of the state's population resides [18]. All participating clinics were primary care facilities, and none specialized in medical care of liver-related diseases. Four physicians recruited 73% of all persons screened at clinics, with 1 physician accounting for 44% of this sample. Although selection of individuals for screening was at the discretion of the participating healthcare provider, physicians were urged to test all of their patients.

Laboratory methods

Two local laboratories analyzed serum samples for the Jade Ribbon Campaign of Hawaii. The first laboratory analyzed the majority of specimens and used the Abbott (Abbott Park, IL) Enzyme-Linked Immunoassay. The second laboratory analyzed the remaining specimens and used the Diagnostic Products Corporation (Los Angeles, CA) Immulite 2000 HBsAg assay. For both laboratories, positive results were confirmed by neutralization testing.

Data collection

All study-related procedures were approved by the Hawaii Pacific Health Institutional Review Board. Data elements extracted from screening records included gender, age (at the time of screening), setting (health fair or clinic), location of health fair (if applicable), and HBsAg status. Because ethnic information was not collected for the screening program database, ethnicity was determined by referencing individual surnames to ethnic or genealogic origin. Determination was conservative, and ethnicity was classified as indeterminate if surname origin could not be verified using published references [24–29]. For females, ethnicity was classified as indeterminate in the event of discrepant origins for first name and surname. Accuracy of surname classification, as measured by the positive predictive value, varies according to ethnic group and ranges from 61 to 96% [28–33]. To prevent miscalculation of prevalence, individuals with multiple screening records (i.e., persons tested more than once) were enrolled as single

subjects and only the most recent age and HBsAg result were considered for the purposes of this study.

A subanalysis of health fair data was also conducted to evaluate the likelihood of HBsAg carriers (i) among fairs with an ethnic focus compared with more ethnically diverse fairs and (ii) among fairs in areas densely populated by Chinese immigrants compared with fairs in areas with higher concentrations of local Chinese. The latter comparison was verified using community census data of the areas surrounding each health fair [34].

Statistical analysis

Following removal of duplicate entries, 3,989 records (2,226 from health fairs and 1,763 from clinics) were included in the statistical analysis. Differences between health fair and clinic samples were compared using chi-square and Mann–Whitney/Wilcoxon tests for categorical and continuous variables, respectively. Univariate and multivariate logistic regression models were used to estimate risk factors for HBV infection. Covariates included gender (female or male), age group (younger than 30, 30–49, 50–69, or 70 or older, in years), and ethnicity (White, Chinese, Japanese, Filipino, Vietnamese, other Asian, or Pacific Islander). A separate model with age (years) as a continuous variable was also considered. All statistical analyses were performed using EpiInfo® Version 3.3.0.0 (Centers for Disease Control and Prevention, Atlanta, GA).

Results

Study population

Characteristics of the 3,989 screened individuals, stratified according to gender, age group, and determined ethnicity, are shown in Table 1. The mean age at screening was 51.4 (SD = 17.1) years and the median age was 51 (range = 0.02–102) years. More than half (59.1%) of participants were female. Chinese, Filipino, and Japanese were the most common ethnicities, with Asians collectively accounting for 81.9% of all screened individuals. The health fair sample contained a higher proportion of females (64.8% vs. 52.0%, $P < 0.001$) and was less likely to be Chinese (31.4% vs. 44.1%, $P < 0.001$) than the clinic-based sample. In addition, the mean age of clinic participants was 44.1 (SD = 14.2) years compared with 57.2 (SD = 17.1) years for health fair participants ($P < 0.001$).

Prevalence

Total prevalence of HBsAg was 3.6% (95% confidence interval [CI]: 3.1–4.3) (Table 2). Prevalence both among

Table 1 Characteristics of participants screened for hepatitis B surface antigen, Hawaii, July 24, 2003, to April 1, 2006

	Percentage of population with characteristic		
	Health fairs (<i>N</i> = 2,226)	Clinics (<i>N</i> = 1,763)	Total (<i>N</i> = 3,989)
Gender*			
Female	64.8	52.0	59.1
Male	34.7	48.0	40.6
No information for gender	0.5	0.1	0.3
Age group (years)*			
Under 30	7.2	16.5	11.3
30–49	23.6	46.1	33.5
50–69	42.0	32.5	37.8
70 or older	25.2	4.2	15.9
No information for age	2.1	0.7	1.5
Ethnicity*			
White	12.6	4.6	9.0
Chinese	31.4	44.1	37.0
Japanese	18.8	5.6	13.0
Filipino	25.3	26.1	25.7
Vietnamese	1.1	8.2	4.2
Other Asian ^a	2.6	1.2	2.0
Pacific Islander ^b	4.0	1.2	2.8
Indeterminate ethnicity	4.2	8.8	6.2

* $P < 0.001$ for group difference between health fair- and clinic-based samples

^a Consisted of Arabic, Asian Indian, Indonesian, Laotian, Thai, Korean, and Malaysian

^b Consisted of Fijian, Hawaiian, Micronesian, Samoan, Tongan, and Marshallese

persons tested at health fairs and among those screened at clinics was 3.2% (95% CI: 2.6–4.1) and 4.1% (95% CI: 3.3–5.2), respectively. The health fair sample did not differ significantly from the clinic sample in overall prevalence or prevalence stratified according to gender, age, or ethnicity.

Males had higher HBsAg prevalence than females (4.6% vs. 3.0%, $P < 0.05$). Prevalence was lowest among participants 70 years or older (1.1%) (Table 2). Pacific Islanders had the highest prevalence of HBsAg among all ethnicities determined for this study (10.7%) (Table 2).

Further stratification indicated that younger Chinese had substantially higher prevalence than older Chinese. In contrast, prevalence among Filipinos was slightly higher in the older age groups (Fig. 1).

Risk factors for HBsAg

Univariate analysis suggested that gender, age, and ethnicity were independently associated with HBsAg

Table 2 Hepatitis B surface antigen prevalence among screening program participants, Hawaii, July 24, 2003, to April 1, 2006

Variable	Percentage positive (no. positive/no. tested)		
	Health fairs	Clinics	Total
Gender			
Female	3.0 (43/1442)	2.9 (27/916)	3.0 (70/2358)
Male	3.8 (29/773)	5.4 (46/846)	4.6 (75/1619)
No information for gender	0 (0/11)	0 (0/1)	0 (0/12)
Age (years)			
Under 30	4.4 (7/160)	5.2 (15/291)	4.9 (22/451)
30–49	3.4 (18/525)	3.7 (30/813)	3.6 (48/1338)
50–69	4.1 (38/934)	4.9 (28/573)	4.4 (66/1507)
70 or older	1.2 (7/561)	0 (0/74)	1.1 (7/635)
No information for age	4.3 (2/46)	0 (0/12)	3.4 (2/58)
Ethnicity			
White	1.4 (4/280)	1.2 (1/81)	1.4 (5/361)
Chinese	6.0 (42/699)	5.5 (43/778)	5.8 (85/1477)
Japanese	0.5 (2/418)	1.0 (1/99)	0.6 (3/517)
Filipino	2.5 (14/564)	3.3 (15/461)	2.8 (29/1025)
Vietnamese	4.2 (1/24)	4.8 (7/145)	4.7 (8/169)
Other Asian ^a	0 (0/58)	4.5 (1/22)	1.3 (1/80)
Pacific Islander ^b	10.0 (9/90)	13.6 (3/22)	10.7 (12/112)
Indeterminate ethnicity	0 (0/93)	1.3 (2/155)	0.8 (2/248)
Overall	3.2 (72/2226)	4.1 (73/1763)	3.6 (145/3989)

* $P < 0.05$ for group difference between health fair- and clinic-based samples

^a Consisted of Arabic, Asian Indian, Indonesian, Laotian, Thai, Korean, and Malaysian

^b Consisted of Fijian, Hawaiian, Micronesian, Samoan, Tongan, and Marshallese

seropositivity. Each of these three variables remained significant predictors of seropositivity when all were included in a multivariate logistic regression model. Risk of HBsAg was significantly elevated for Vietnamese (odds ratio [OR] = 3.24, 95% CI: 1.04–10.09), Chinese (OR = 4.13, 95% CI: 1.66–10.29), and Pacific Islanders (OR = 7.47, 95% CI: 2.52–22.11) compared with Whites. Males were at increased risk for HBsAg seropositivity (OR = 1.53, 95% CI: 1.09–2.16) compared with females. Persons aged 70 years or older had a significantly lower risk (OR = 0.25, 95% CI: 0.11–0.61) than those younger than 29 years (Table 3).

The multivariate logistic regression model with grouped age categories suggested a nonlinear relation between age and HBsAg seropositivity. Similar conclusions were apparent from the significance of a quadratic age term

when age is utilized as a continuous variable (data not shown). As shown in Table 3, ORs for HBV infection drastically declined by age 70.

Differences among health fairs and clinics

A higher likelihood of chronic HBV infection among clinic participants was suggested than those screened at health fairs, although the difference was not statistically significant ($P = 0.13$) (Table 4). Odds for HBsAg carriers were higher for health fairs in areas densely populated by Chinese immigrants (OR = 12.32, 95% CI: 5.23–29.05) and a Micronesian fair (OR = 17.76, 95% CI: 5.98–52.75) than for more ethnically diverse fairs (Table 4). In addition, fairs in areas with large populations of Chinese immigrants had higher odds of HBsAg-positive persons (OR = 6.02, 95% CI: 1.85–19.58) than fairs in areas dominated by Chinese born locally in Hawaii (Table 4). However, fairs in areas with large numbers of local Chinese had a much higher percentage of persons aged 70 years or older than fairs in areas densely populated by Chinese immigrants (49.0% vs. 16.7%, $P < 0.001$).

Discussion

Total prevalence of HBsAg among Hawaii residents in our study (3.6%) is greater than the 2.1% prevalence rate from 1970 reported by Diwan et al. [22]. The relative sensitivities of the assays used in our study and the prevaccine survey (enzyme immunoassay and radioimmunoassay, respectively) are both classified as high [35]. It should be noted, however, that only 44 (5.5%) of the 799 residents sampled by Diwan et al. were born outside of the United States. Although the exact number of foreign-born participants in our study is unknown, the fact that 15.2% of our sample was recruited at health fairs in areas densely populated by Chinese immigrants suggests that the present study contained a larger proportion of foreign-born persons than the survey conducted by Diwan et al. This characteristic may be responsible for our study's higher prevalence because immigrants from highly endemic countries account for a disproportionate share of the chronically infected population in the United States [1].

Total hepatitis B prevalence for our study is substantially lower within the past 5 years than for similar culturally targeted HBV screening programs in other major U.S. cities [13–17]. This discrepancy is possibly related to a lower proportion of foreign-born immigrants in our sample (percentages of foreign-born for other recent programs are as high as 98.9%). Unlike other U.S. screening programs that tend to focus upon Asian Americans, our study also included Whites, who are

Fig. 1 Hepatitis B surface antigen (HBsAg) prevalence among males (*top panel*) and among females (*bottom panel*) stratified by age and ethnicity, Hawaii, July 24, 2003, to April 1, 2006. *White bars*, persons younger than 30 years; *bars with dots*, persons aged 30–49 years; *bars with diagonal lines*, persons aged 50–69 years; *black bars*, persons aged 70 years or older

Table 3 Univariate and multivariate analyses of risk factors for hepatitis B surface antigen seropositivity among screening participants, Hawaii, July 24, 2003, to April 1, 2006

	Univariate ^a		Multivariate ^a	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
Gender				
Female	1.00 (reference)	–	1.00 (reference)	–
Male	1.62*	1.16–2.27	1.53*	1.09–2.16
Age				
Under 30	1.00 (reference)	–	1.00 (reference)	–
30–49	0.74	0.44–1.26	0.67	0.39–1.16
50–69	0.91	0.55–1.50	0.83	0.49–1.40
70 or older	0.22**	0.09–0.51	0.25*	0.11–0.61
Ethnicity				
White	1.00 (reference)	–	1.00 (reference)	–
Chinese	4.23*	1.70–10.51	4.13*	1.66–10.29
Japanese	0.41	0.10–1.73	0.51	0.12–2.15
Filipino	2.04	0.78–5.30	2.02	0.77–5.26
Vietnamese	3.48*	1.12–10.81	3.24*	1.04–10.09
Other Asian ^b	0.89	0.10–7.70	0.84	0.10–7.27
Pacific Islander ^c	7.85**	2.66–23.13	7.47**	2.52–22.11

* $P < 0.05$; ** $P < 0.001$

^a Excludes 304 participants missing information for age, sex, or ethnicity

^b Consisted of Arabic, Asian Indian, Indonesian, Laotian, Thai, Korean, and Malaysian

^c Consisted of Fijian, Hawaiian, Micronesian, Samoan, Tongan, and Marshallese

generally at lower risk for HBV than Asians. Likewise, our study sampled lower-risk Asians, such as Filipinos and Japanese, and less higher-risk Asians, such as Chinese and Koreans, than programs in other U.S. cities. Finally, the Jade Ribbon Campaign of Hawaii did not offer free treatment for seropositive persons, whereas a

screening program in New York City provided such services and was more likely to attract HBsAg carriers seeking free medical care. In the New York City program, prevalence was much higher among those who had prior testing than among those who had not been previously screened (24.0% vs. 14.8%) [16].

Table 4 Differences in prevalence of hepatitis B surface antigen among health fairs and clinics, Hawaii, July 24, 2003, to April 1, 2006

	Odds ratio	95% Confidence interval
Screening settings		
Health fairs	1.00 (reference)	–
Clinics	1.29	0.93–1.80
Health fairs		
Ethnically diverse fairs	1.00 (reference)	–
Chinese immigrant fairs	12.32**	5.23–29.05
Local Chinese fairs	2.05	0.51–8.25
Filipino fairs	2.45	0.74–8.10
Micronesian fair	17.76**	5.98–52.75
Neighborhood fairs	2.33	0.65–8.33
Immigrant density surrounding health fairs		
Local Chinese fairs	1.00 (reference)	–
Chinese immigrant fairs	6.02*	1.85–19.58

* $P < 0.05$; ** $P < 0.001$

The higher prevalence among males in Hawaii is in agreement with recent seroprevalence studies conducted in California and New York [12, 15, 16]. The nonlinear relationship between age and HBsAg prevalence that was found in this study has also been reported elsewhere, most notably by serologic surveys in Singapore and Korea [36, 37]. Significantly lower risk for HBsAg in persons aged 70 years or older might have resulted from spontaneous clearance of HBsAg over time (a 40% cumulative rate of HBsAg seroclearance has been observed among HBV carriers after 25 years) [38]. In addition, mortality due to HBV-related sequelae may lead to decreased prevalence by age 70 (probability of survival is 84% at 5 years and 68% at 10 years for HBsAg-seropositive patients with compensated cirrhosis) [39]. Following stratification by gender, age, and ethnicity, prevalence decreased with age among most ethnicities in this study. For Filipino participants, however, prevalence increased with age. One explanation for this deviation might be a higher proportion of low-risk, locally born persons among the younger Filipino age groups than among the older Filipinos. In addition, the exact birthplace of foreign-born Filipinos in our sample might also be responsible for prevalence increasing with age in this ethnic group because specific areas within the Philippines have demonstrated late peaks of HBsAg seropositivity [40].

With the exception of ethnic Japanese, prevalence for the ethnicities in this study is lower in Hawaii than rates in the corresponding native countries [35, 41, 42]. This observation might again be attributable to low proportions of foreign-born individuals in our study sample and more consistent preventive strategies in Hawaii such as

screening programs for adults with high-risk behaviors [23]. Although the observed prevalence in Whites (1.4%) was lower than in most other ethnicities, it is almost 4 times the estimate for the general U.S. population (0.4%) [11]. Increased exposure via inter-ethnic marriage with higher risk ethnic groups might be one explanation for this finding and remains an area of interest for future epidemiologic studies of hepatitis B in Hawaii.

Patients in clinical settings are more likely to have medical conditions (e.g., symptoms of hepatitis) than persons attending health fairs. Furthermore, selected clinics in this study might have included a high-risk Asian immigrant population similar to that at the health fairs. For these reasons, the increased likelihood of chronic HBV carriers at clinics compared with health fairs was expected, although this difference was not statistically significant. In the sub-analysis of health fairs, large numbers of high-risk Chinese and Pacific Islanders attending fairs with an ethnic focus are likely responsible for the higher odds of seropositive participants at Chinese immigrant fairs and a Micronesian fair than at more ethnically diverse fairs. In addition, the higher odds for infected persons at fairs densely populated by Chinese immigrants than at fairs in areas dominated by locally born Chinese are probably due to fairs in areas with large numbers of local Chinese having a significantly higher proportion of low-risk participants aged 70 or older. Moreover, foreign-born Chinese are less likely to be protected against HBV transmission, as evidenced by vaccination coverage rates as low as 29% in remote areas of China [42]. From a public health perspective, our observed difference in prevalence between Chinese immigrants and those born locally underscores the significance of Hawaii's current vaccination strategies for high-risk adults and suggests that birthplace is a significant predictor of HBsAg seropositivity in Hawaii.

The strengths of our study include a large sample size and its setting in the diverse environment of Hawaii. Inclusion of Whites is particularly unique and offers valuable insight into the potential HBV disease burden for this ethnic group. To the best of our knowledge, this study is also the first to compare HBV screening outcomes between health fairs and clinics.

One limitation of our study is the nonrandom recruitment of screening participants associated with the source database. Thus, our sample might not be representative of Hawaii's general population, which is younger (median age = 36.2 years) and less likely to be female (49.8%) [18]. Over representation of high-risk Asians (81.9% in our sample vs. 42% in Hawaii's total population) might have resulted in over estimation of total prevalence, although any such bias was likely counterbalanced by over representation of low-risk female participants and those aged 70 or older. A second limitation is the variable accuracy for our method

of ethnic classification via surnames. The positive predictive value is comparable among Asian surname lists (83–93%) [29], but this value is low for Hispanic surnames (69%) [30]. Although this difference might have led to higher mis-classification of Hispanics in our sample, the impact is likely negligible due to the minute number of Hispanic surnames in the screening database. Finally, ethnic classification via surnames is difficult for multiracial individuals, adoptees, and persons with surname changes [32]. However, as previously mentioned, we minimized the inaccuracies of this method by conservative assessment of females and persons with unverifiable surname origins. Overall, the sufficient degree of accuracy at the ethnic group aggregate level supports surname classification as a valid alternative for assigning ethnicity when self-identification is unavailable [33].

The findings of this study add to the current knowledge of hepatitis B epidemiology in areas with sizable high-risk groups and demonstrate the importance of screening programs for hepatitis B. Mass screening permits baseline estimates of prevalence and provides insight into appropriate vaccination strategies. Furthermore, because of Hawaii's high incidence of hepatitis B-related hepatocellular carcinoma [43] and high prevalence of HBV genotype C (which has been strongly associated with adverse outcomes) [44, 45], screening programs are clinically significant for facilitating referral of newly diagnosed cases to appropriate medical care [13, 14]. As the Asia-Pacific region continues to experience barriers in disease management [42] and more robust studies substantiate high endemicity in areas of eastern Europe [35, 46], chronic hepatitis B will persist as an important public health concern for Hawaii and other metropolitan areas with large populations of high-risk immigrants.

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References

- Mast EE, Weinbaum CM, Fiore EA, Alter MJ, Bell BP, Finelli L, et al. A comprehensive immunization strategy to eliminate transmission of hepatitis B virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices (ACIP). Part II: immunization of adults. *MMWR Recomm Rep* 2006;55(RR-16):1–33
- Lok AS, McMahon BJ. Chronic hepatitis B. *Hepatology* 2007;45:507–539. doi:10.1002/hep.21513
- Lok AS, McMahon BJ. Corrections to AASLD Practice Guidelines on chronic hepatitis B. *Hepatology*. 2007;45:1347. doi:10.1002/hep.21738
- Liaw YF, Tai DI, Chu CM, Chen TJ. The development of cirrhosis in patients with chronic type B hepatitis: a prospective study. *Hepatology* 1988;8:493–496. doi:10.1002/hep.1840080310
- Fattovich G, Brollo L, Giustina G, Noventa F, Pontisso P, Alberti A, et al. Natural history and prognostic factors for hepatitis B. *Gut* 1991;32:294–298. doi:10.1136/gut.32.3.294
- McMahon BJ, Alberts SR, Wainwright RB, Bulkow L, Lanier AP. Hepatitis-B-related sequelae: prospective study in 1400 hepatitis B surface antigen-positive Alaska native carriers. *Arch Intern Med* 1990;150:1051–1054. doi:10.1001/archinte.150.5.1051
- Fattovich G, Pantalena M, Zagni I, Realdi G, Schalm SW, Christensen E. Effect of hepatitis B and C virus infection on the natural history of compensated cirrhosis: a cohort study of 297 patients. *Am J Gastroenterol* 2002;97:2886–2895. doi:10.1111/j.1572-0241.2002.07057.x
- Chen CJ, Liang KY, Chang AS, Chang YC, Lu SN, Liaw YF, et al. Effects of hepatitis B virus, alcohol drinking, cigarette smoking and familial tendency of hepatocellular carcinoma. *Hepatology* 1991;13:398–406
- Yang HI, Lu SN, Liaw YF, You SL, Sun CA, Wang LY, et al. Hepatitis B e Antigen and the risk of hepatocellular carcinoma. *N Engl J Med* 2002;347:168–174. doi:10.1056/NEJMoa013215
- Chen CJ, Yang HI, You SL. Hepatitis B e antigen and the risk of hepatocellular carcinoma [reply]. *N Engl J Med* 2002;347:1721–1722. doi:10.1056/NEJM200211213472119
- McQuillan GM, Coleman PJ, Kruszon-Moran D, Moyer LA, Lambert SB, Margolis HS. Prevalence of hepatitis B virus infection in the United States: the National Health and Nutrition Examination Surveys, 1976 through 1994. *Am J Public Health* 1999;89:14–18
- Tong MJ, Hwang SJ. Hepatitis B virus infection in Asian Americans. *Gastroenterol Clin North Am* 1994;23:523–536
- Guane R, Siu P, Lam K, Kim KE, Warren V, Liu H, et al. Prevalence of HBV and risk of HBV acquisition in hepatitis B screening programs in large metropolitan cities in the United States [abstract]. *Hepatology* 2004;40(4 Suppl 1):716A
- Chao S, Le VP, Prapong W, Su J, So S. High prevalence of chronic hepatitis B (HBV) infection in adult Chinese Americans living in California [abstract]. *Hepatology* 2004;40(4 Suppl 1):717A
- Lin SY, Chang ET, So SK. Why would should routinely Asian American adults for hepatitis B: a cross-sectional study of Asians in California. *Hepatology* 2007;46:1034–1040. doi:10.1002/hep.21784
- Centers for Disease Control and Prevention. Screening for chronic hepatitis B among Asian/Pacific Islander populations—New York City, 2005. *MMWR Morb Mortal Wkly Rep* 2006;55:505–509
- Hsu CE, Liu LCH, Juon HS, Chiu YW, Bawa J, Tillman U, et al. Reducing liver cancer disparities: a community-based hepatitis-B prevention program for Asian-American communities. *J Natl Med Assoc* 2007;99:900–907
- Hawaii: 2000, Census 2000 Profile. Washington (DC): US Census Bureau, Economics and Statistics Administration, US Department of Commerce; 2002. <http://www.census.gov/prod/2002pubs/c2kprof00-hi.pdf>
- Domestic Net Migration in Hawaii. 2000–2004. Honolulu (HI): Research and Economic Analysis Division, Hawaii State Department of Business, Economic Development & Tourism; 2006
- Shepard CW, Simard EP, Finelli L, Fiore AE, Bell BP. Hepatitis B virus infection: epidemiology and vaccination. *Epidemiol Rev* 2006;28:112–125. doi:10.1093/epirev/mxj009

21. Foreign-Born Profiles (STP-159). Hawaii, Top 10 Countries of Birth. Washington (DC): Immigration Statistics Staff, Population Division, US Census Bureau; 2004. <http://www.census.gov/population/www/socdemo/foreign/fbpHL.html>
22. Diwan A, Thanh NT, Halstead SB. Hepatitis B virus (HBV) infections and primary hepatocellular carcinoma in Hawaii and South Pacific Islands. In Mackenzie JS, editor. *Viral Diseases in South-East Asia and the Western Pacific*. Sydney: Academic Press; 1982. 375–381
23. Communicable Disease Report. September/October 2004. Honolulu (HI): Communicable Disease Division, Hawaii State Department of Health; 2004. http://www.state.hi.us/health/family-child-health/contagious-disease/comm-disease/cdr/cdr_2004sepoct.pdf
24. Hanks P. *Dictionary of American Family Names*. New York: Oxford University Press; 2003
25. Jones R. *Chinese Names: The Traditions Surrounding the Use of Chinese Surnames and Personal Names*. Petaling Jaya, Selangor: Pelanduk Publications; 1997
26. US Central Intelligence Agency. *Vietnamese Personal Names*. Washington (DC): US Central Intelligence Agency; 1961
27. Agin R. *Guide to the Pronunciation of Asian Pacific Names*. Hayward, CA: Asian American Educator's Council, California State University; 1993
28. Choi BCK, Hanley AJG, Holowaty EJ, Dale D. Use of surnames to identify individuals of Chinese ancestry. *Am J Epidemiol* 1993;138:723–734
29. Lauderdale DS, Kestenbaum B. Asian American ethnic identification by surname. *Popul Res Policy Rev* 2000;19:283–300. doi:10.1023/A:1026582308352
30. Steward SL, Swallen KC, Glaser SL, Horn-Ross PL, West DW. Comparison of methods for classifying Hispanic ethnicity in a population-based cancer registry. *Am J Epidemiol* 1999;149:1063–1071
31. Swallen KC, Glaser SL, Steward SL, West DW, Jenkins CNH, McPhee SJ. Accuracy of racial classification of Vietnamese patients in a population-based cancer registry. *Ethn Dis* 1998;8:218–227
32. Fiscella K, Fremont AM. Use of geocoding and surname analysis to estimate race and ethnicity. *Health Serv Res* 2006;41:1482–1500
33. Mateos P. A review of name-based ethnicity classification methods and their potential in population studies. *Popul Space Place* 2007;13:243–263. doi:10.1002/psp.457
34. American Community Survey 2005 Hawaii Geographic Area Profiles. Honolulu, HI: Department of Business, Economic Development & Tourism, State of Hawaii/Washington, DC: American Community Survey, US Census Bureau; 2005. http://www.hawaii.gov/dbedt/info/census/acs_hi_2005_folder/acs_hi_2005_profiles
35. Custer B, Sullivan SD, Hazlet TK, Iloeje U, Veenstra DL, Kowdley KV. Global epidemiology of hepatitis B virus. *J Clin Gastroenterol* 2004;38 Suppl 3:S158–S168. doi:10.1097/00004836-200411003-00008
36. James L, Fong CW, Foong BH, Wee MK, Chow A, Shum E, et al. Hepatitis B seroprevalence study 1999. *Singapore Med J* 2001;42:420–424
37. Lee DH, Kim JH, Nam JJ, Kim HR, Shin HR. Epidemiological findings of hepatitis B infection based on 1998 National Health and Nutrition Survey in Korea. *J Korean Med Sci* 2002;17:457–462
38. Chu CM, Liaw YF. HBsAg seroclearance in asymptomatic carriers of high endemic areas: appreciably high rates during a long-term follow-up. *Hepatology* 2007;45:1187–1192. doi:10.1002/hep.21612
39. Realdi G, Fattovich G, Hadziyannis S, Schalm SW, Almasio P, Sanchez-Tapias J, et al. Survival and prognostic factors in 366 patients with compensated cirrhosis type B: a multicenter study. *J Hepatol* 1994;21:656–666. doi:10.1016/S0168-8278(94)80115-0
40. Lansang MAD. Epidemiology and control of hepatitis B infection: a perspective from the Philippines, Asia. *Gut* 1996;38:S43–S47. doi:10.1136/gut.38.Suppl_2.S43
41. Merican I, Guan R, Amarapura D, Alexander MJ, Chutaputti A, Chien RN, et al. Chronic hepatitis B virus infection in Asian countries. *J Gastroenterol Hepatol* 2000;15:1356–1361. doi:10.1046/j.1440-1746.2000.0150121356.x
42. Lesmana LA, Leung NWY, Mahachai V, Phiet PH, Suh DJ, Yao GB, et al. Hepatitis B: overview of the burden of disease in the Asia-Pacific region. *Liver Int* 2006;26:3–10. doi:10.1111/j.1478-3231.2006.01370.x
43. Wong LL, Limm WM, Tsai N, Severino R. Hepatitis B and alcohol effect survival of hepatocellular carcinoma patients. *World J Gastroenterol* 2005;11:3491–3497
44. Sakurai M, Sugauchi F, Tsai N, Suzuki S, Hasegawa I, Fujiwara K, et al. Genotype and phylogenetic characterization of hepatitis B virus among multi-ethnic cohort in Hawaii. *World J Gastroenterol* 2004;10:2218–2222
45. Fung SK, Lok ASF. Hepatitis B virus genotypes: do they play a role in the outcome of HBV infection? *Hepatology* 2004;40:790–792
46. Nothdurft HD, Dahlgren AL, Gallagher EA, Kollaritsch H, Overbosch D, Rummukainen ML, et al. The risk of acquiring hepatitis A and B among travelers in selected eastern and southern Europe and non-European Mediterranean countries: review and consensus statement on hepatitis A and B vaccination. *J Travel Med* 2007;14:181–187. doi:10.1111/j.1708-8305.2007.00123.x