A SPATIAL STUDY OF AIDS SURVEILLANCE DATA BY DEMOGRAPHIC SUBGROUPS IN CALIFORNIA

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"It began, like so many epidemics, with a few isolated cases, a whisper that caught the ear of only a few in medical research. Today, that whisper has become a roar heard around the world."

Antonia Coello Novello, M.D., M.P.H. *Surgeon General's Report to the American Public on HIV Infection and AIDS, 1992*.

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EXECUTIVE SUMMARY

Objectives. Our objectives were to: 1) obtain an epidemiolological profile of AIDS incidence for six demographic subgroups in the state of California; 2) examine the spatial distribution of AIDS incidence within each demographic subgroup; 3) compare AIDS incidence in individual California counties to the overall statewide rate; and 4) highlight counties with high AIDS incidence in the state of California.

Design. Age-adjusted AIDS incidence rates were calculated from 1998 California AIDS surveillance data for six demographic subgroups. Subgroups examined were; White (non-Hispanic) males, Black (non-Hispanic) males, Hispanic Males, White (non-Hispanic) Females, Black (non-Hispanic) females, and Hispanic females. A geographic information system (GIS) was used to construct maps of California county level AIDS incidence for each demographic subgroup. An asymptotic z-test was used to compare AIDS incidence rates in each county with the overall statewide rate.

Results. Each of the six demographic subgroups has a specific epidemiological picture of AIDS incidence as shown by the maps contained in this report. San Francisco is the county with the highest reliable rate of AIDS incidence for White (non-Hispanic) males, Hispanic males, Black (non-Hispanic) females, and Hispanic females. Kings County has the highest reliable rate of AIDS incidence for Black (non-Hispanic) males.

Conclusion. AIDS incidence in California varies widely between different demographic subgroups. Proper understanding of the specific characteristics of the AIDS epidemic in different California demographic subgroups is vital for effective policy and prevention programs.

INTRODUCTION

Study of the spatial distribution of disease and health-related events in populations is a powerful tool for setting priorities for investigation and control. Spatial analysis may assist public health officials in deciding where disease prevention efforts should be focused. They can further be used for evaluating the efficacy of intervention programs and to determine what type of treatment facilities are needed in a given area.

The significant role of geographic patterns in public health dates back to the mid-1800's, when John Snow, a British physician, identified the source of a cholera outbreak by plotting the locations of cholera deaths in central London (1). In the modern era, Denis Burkitt hypothesized a viral etiology for Burkitt's Lymphoma after studying the spatial distribution of the disease in central Africa (2). In recent years, mapping health outcomes at the local level using geographic information systems (GIS) has become an important tool in identifying areas in need of intervention (3-6). There is a growing body of literature emphasizing and reshaping the important role of GIS as a tool in assisting health professionals and public health decision makers to improve the health status of communities (7-16).

The goal of this study is to assist public health officials and policy makers to identify the areas of greatest need for HIV/AIDS prevention and resource allocation. In order to accomplish this goal, age-adjusted incidence rates of AIDS in each of several major demographic subgroups are presented in the form of incidence maps at the county level. The demographic subgroups examined in this study included; White (non-Hispanic) men, Black (non-Hispanic) men, Hispanic men, White (non-Hispanic) women, Black (non-Hispanic) women, and Hispanic women. Age-adjusted standardized incidence rates for each county in the state of California were calculated. We used 1997 county, gender, age, and race/ethnicity specific population estimates for the state (17) to estimate incidence rates.

In California, AIDS incidence rates vary dramatically between demographic subgroups, as well as between counties. Thus, analysis at the county level may allow public health officials to design and implement intervention programs that are sensitive to the needs of historically underrepresented groups, as well as illustrate the increasing health disparity in the State.

SOURCES OF DATA

California AIDS Surveillance Data

Healthcare providers in California are required by law to confidentially report persons with AIDS to local health departments. Information on AIDS patient demographics, clinical status, and modes of exposure to HIV are recorded on standardized forms and forwarded to the AIDS case registry at the California Department of Health Services. For this study, we analyzed all AIDS cases reported to the registry in 1998.

Population Estimate Data

The 1997 population estimates for each of the 58 counties in California served as reference populations for the calculation of county specific incidence rates.

METHODS

The incidence of AIDS varies by gender, and among different race/ethnicities and age groups. In this study, we reported the age-adjusted incidence rates for each gender and race/ethnicity specific demographic subgroup. The categories for gender were male and female, and for race/ethnicity the categories were Black (non-Hispanic), White (non-Hispanic), and Hispanic. The age groups considered in this study were 0-17, 18-34, 34-54, and 55 years and over.

The gender and race/ethnicity-specific standardized incidence rates of AIDS in each county were calculated per 100,000 population. The crude incidence rate for the i^{th} county, j^{th} gender (male, female), k^{th} race-ethnicity (White [non-Hispanic], Black [non-Hispanic], or Hispanic), and l^{th} age group (0-17, 18-34, 35-54, or 55 and over) was denoted by r_{ijkl} and calculated according to the following formula:

$$r_{ijkl} = \frac{d_{ijkl}}{n_{ijkl}} \times 100{,}000$$

where d_{ijkl} and n_{ijkl} represent the corresponding number of AIDS cases and the State

estimate of the population respectively. The age-adjusted incidence rate is then calculated by:

$$R_{ijk} = \frac{\sum_{l} n_{jkl} \times r_{ijkl}}{\sum_{l} n_{jkl}}$$

where the weights n_{jkl} represent the State estimate of the population for the j^{th} gender, k^{th} race/ethnicity, and l^{th} age group in the county. A similar procedure was followed to obtain the adjusted incidence rate for the entire state.

Computing the coefficients of variation assessed the reliability of the estimated incidence rates. Binomial mean and standard deviation, as an approximation for the Poisson distribution, were used in the calculation of the coefficients of variation. Estimated incidence rates with coefficients of variation greater than 0.23 were considered unreliable.

The gender and race/ethnicity-specific incidence rates for each county were then compared with the corresponding statewide rates by computing the ratio of the incidence rate of each county to the statewide rate. A two-tailed, asymptotic z-test was performed to evaluate the difference between the calculated county and statewide incidence rates at the 0.05 level of significance.

In order to identify the counties with noticeably higher AIDS incidence rates, we placed counties into three categories based on the results of the asymptotic z-tests: counties with significantly higher incidence than the statewide rate, counties with significantly lower incidence than the statewide rate, and counties with incidence not significantly different than the statewide rate.

Sorting the non-zero adjusted rates and identifying the percentiles of the empirical frequency distribution ranked the age-adjusted incidence rates of each county, within each demographic sub-group. The rates were then classified into one of seven ranking categories: 1) lower 10 percent, 2) lower 10-20 percent, 3) lower 20-40 percent, 4) middle 40-60 percent, 5) upper 60-80 percent, 6) upper 80-90 percent and 7) upper 10 percent. The ranking for each geographic region, as well as the upper and lower limits for the seven ranking categories were reported. We also examined the frequency distribution of ratios of county incidence rates to the corresponding statewide values. The lower and upper bounds of the above-mentioned seven ranking categories were also reported for the ratios.

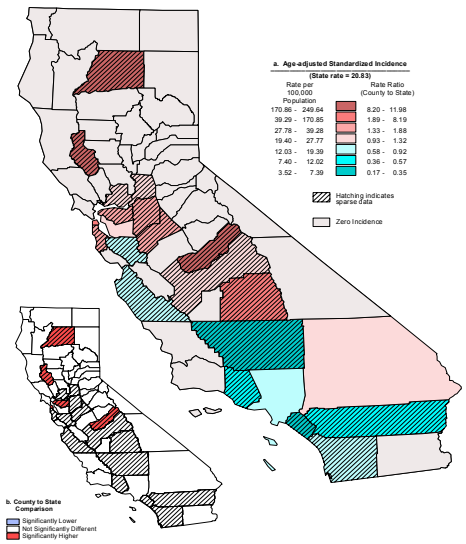
Statistical Analysis System (SAS) v. 8.0 (18) was used for the initial extraction of the incidence data. Microsoft Excel was used for file manipulation at different stages of data preparation. A customized program in QBasic was written to merge the population and incidence data. Another Qbasic program was written to perform all necessary computations and hypothesis testing for the study.

Maps of AIDS age-adjusted standardized incidence rates at the county level for each demographic sub-group were created in ESRI Arcview v. 3.2 by merging the incidence rate data with ESRI's California county digital maps. Additionally, maps of statistically higher, lower, or not different, age-adjusted standardized incidence rates were created by merging asymptotic z-test results with the California county digital maps.

Interpreting the Maps

Two maps were created for each demographic subgroup. An example of the two maps is shown below in Figure 1. The larger map represents the age-adjusted standardized AIDS incidence rates per 100,000 people by county classified into seven ranking categories. The smaller map presents individual county rates compared with the State incidence rate. Counties with significantly higher incidence rates compared to the State incidence rate are colored red, counties with significantly lower incidence rates appear in blue, and counties with not significantly different rates than the State rate appear in white. Light gray shading indicates counties where the age-adjusted AIDS incidence rate equals zero. For both maps, a hatched pattern is used to denote counties with unreliable estimated incidence rates due to sparse data.

Figure 1. Example Map



RESULTS

White (non-Hispanic) Males

The 1998 statewide California age-adjusted standardized incidence rate for White (non-Hispanic) males was 20.09 per 100,000 population (population size = 12,824,406). The county-level incidence rates among White (non-Hispanic) males ranged from 0.00 to 221.72 per 100,000 population (Figure 2a). Table 1 presents the five counties with the highest AIDS incidence rates.

Table 1. Highest county-specific incidence rates for White (non-Hispanic) males.

County	Rate (per/100,000)	Population
San Francisco	221.72	200,722
Lake*	40.00	25,674
Mariposa*	38.95	7,794
Kings*	37.16	50,797
Marin	34.60	101,100

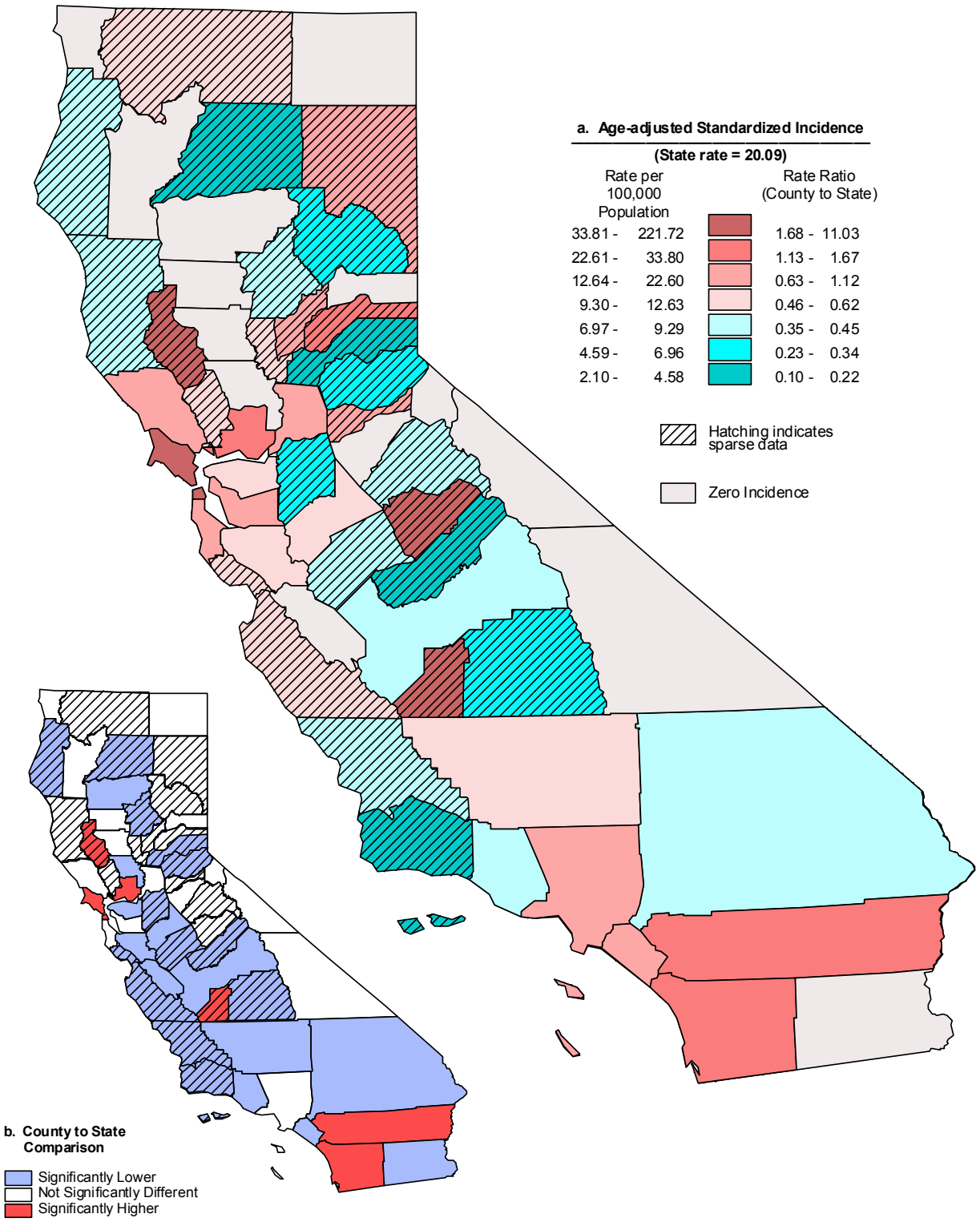
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There were five counties with reliable incidence rates that had significantly higher rates compared to the State rate (Figure 2b). The five counties were San Francisco (rate ratio [RR] = 11.03), Marin (RR = 1.72), Riverside (RR = 1.62), Solano (RR = 1.54), and San Diego (RR = 1.28).

Figure 2. Incidence Rates by County, 1998

AIDS
White (non Hispanic) Male



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

Black (non-Hispanic) Males

The California age-adjusted standardized incidence rate for Black (non-Hispanic) males was 83.38 per 100,000 population (population size = 1,217,344). The county-level incidence rates among Black (non-Hispanic) males ranged from 0.00 to 524.16 per 100,000 population (Figure 3a). Table 2 presents the five counties with the highest AIDS incidence rates.

Table 2. Highest county-specific incidence rates for Black (non-Hispanic) males.

County	Rate (per/100,000)	Population
Tuolumne*	524.16	185
Kings	369.00	6,236
San Francisco	270.04	39,663
Lassen*	144.00	1,840
Kern	131.09	21,014

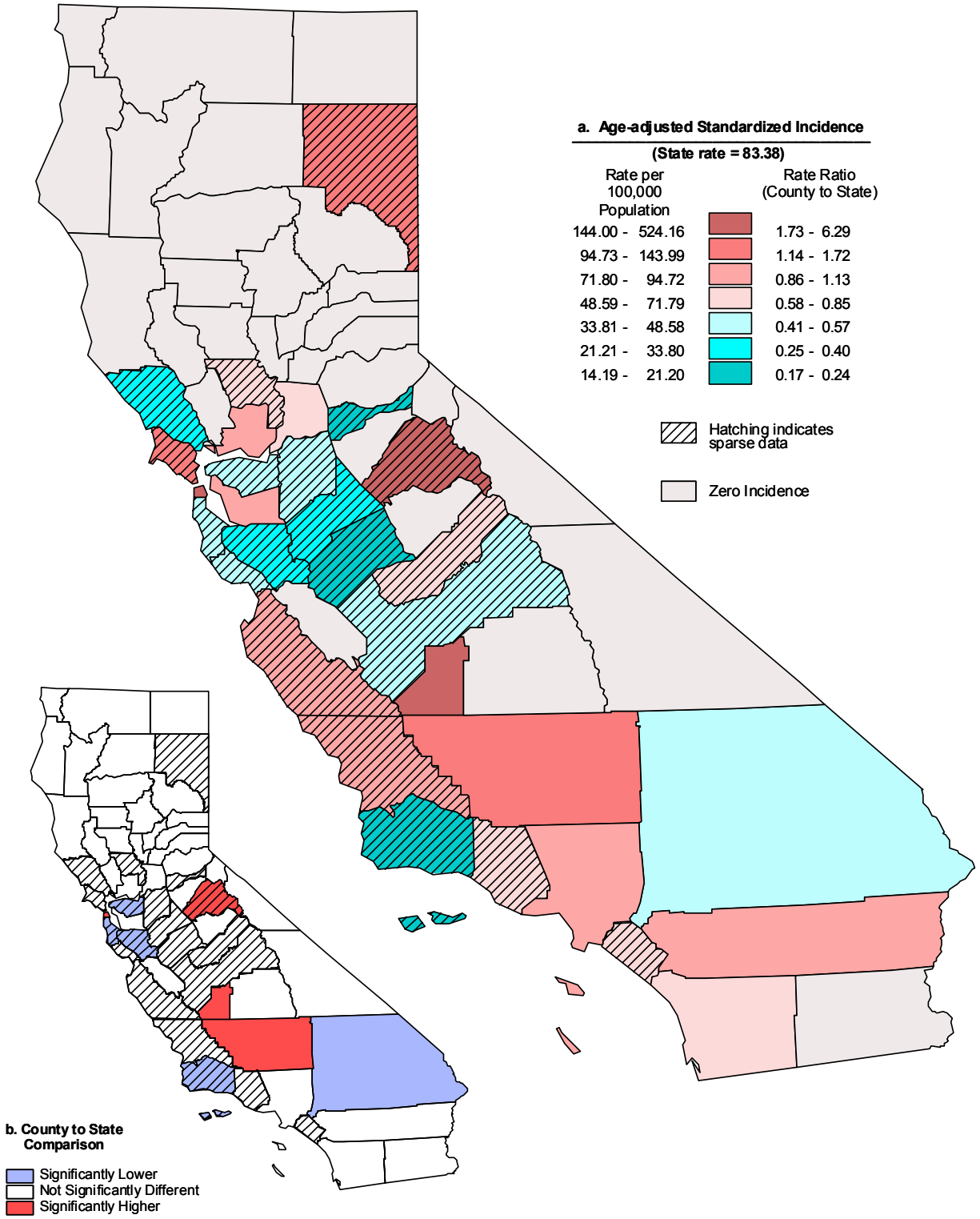
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There were three counties with reliable incidence rates that had significantly higher rates compared to the State rate (Figure 3b). The three counties were Kings (RR = 4.43), San Francisco (RR = 3.24), and Kern (RR = 1.57)

Figure 3. Incidence Rates by County, 1998

AIDS
Black (non Hispanic) Male



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

Hispanic males

The California age-adjusted standardized incidence rate for Hispanic males was 27.53 per 100,000 population (population size = 5,023,544). The county-level incidence rates among Hispanic males ranged from 0.00 to 122.21 per 100,000 population (Figure 4a). Table 3 presents the five counties with the highest AIDS incidence rates.

Table 3. Highest county-specific incidence rates for Hispanic males.

County	Rate (per/100,000)	Population
San Francisco	122.21	59,913
Calaveras*	58.32	1,482
Kings*	53.69	25,542
Solano*	49.22	32,653
Tuolumme*	45.30	1,899

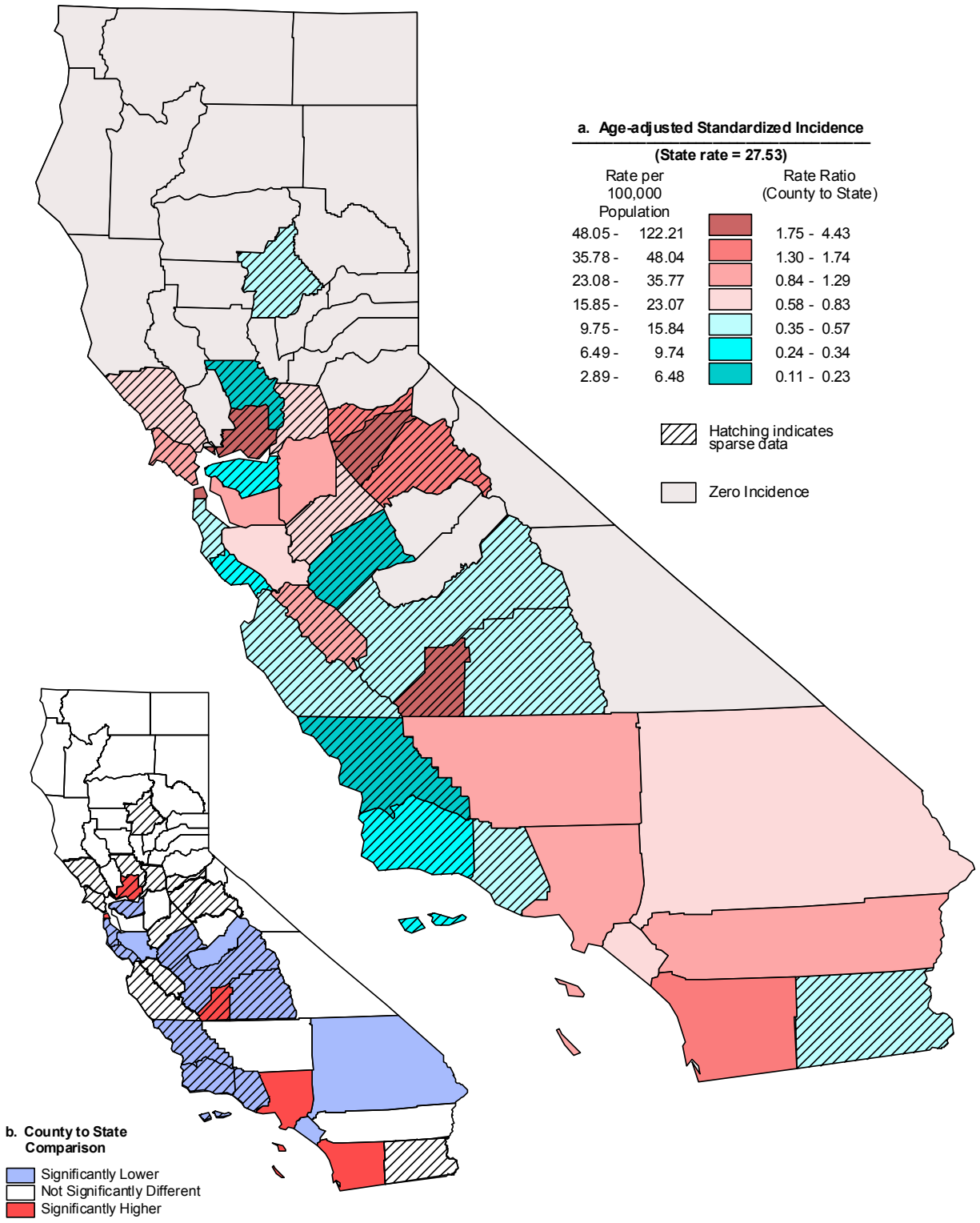
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There were three counties with reliable incidence rates that had significantly higher rates compared to the State rate (Figure 4b). The three counties were San Francisco (RR = 4.44), San Diego (RR = 1.33), and Los Angeles (RR = 1.28)

Figure 4. Incidence Rates by County, 1998

AIDS
Hispanic Male



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

White (non-Hispanic) females

The California age-adjusted standardized incidence rate for White (non-Hispanic) females was 1.65 per 100,000 population (population size = 12,768,001). The county-level incidence rates among White (non-Hispanic) females ranged from 0.00 to 6.78 per 100,000 population (Figure 5a). Table 4 presents the five counties with the highest AIDS incidence rates.

Table 4. Highest county-specific incidence rates for White (non-Hispanic) females.

County	Rate (per/100,000)	Population
Nevada*	6.78	43,143
Sutter*	6.60	32,513
San Francisco*	5.59	190,463
Lake*	4.24	26,669
Madera*	4.21	51,545

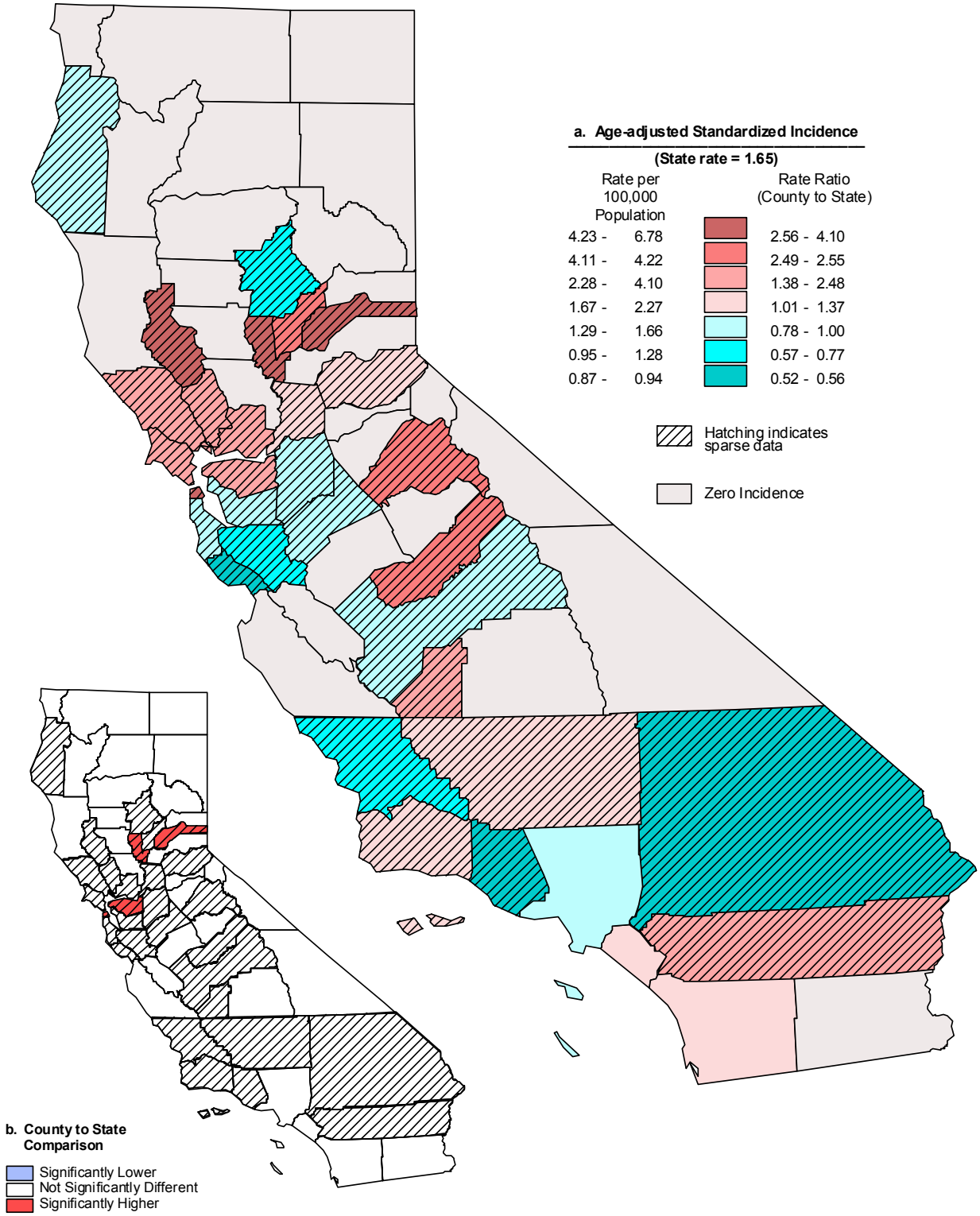
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There were no counties with reliable incidence rates that had significantly higher rates compared to the state rate (Figure 5b).

Figure 5. Incidence Rates by County, 1998

AIDS
White (non-Hispanic) Female



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

Black (non-Hispanic) Females

The California age-adjusted standardized incidence rate for Black (non-Hispanic) females was 20.83 per 100,000 population (population size = 1,233,786). The county-level incidence rates among Black (non-Hispanic) females ranged from 0.00 to 249.64 per 100,000 population (Figure 6a). Table 5 presents the five counties with the highest AIDS incidence rates.

Table 5. Highest county-specific incidence rates for Black (non-Hispanic) females.

County	Rate (per/100,000)	Population
Lake*	249.64	547
Shasta*	227.31	572
Madera*	198.19	1,846
San Francisco	61.54	40,920
Tulare*	41.67	2,910

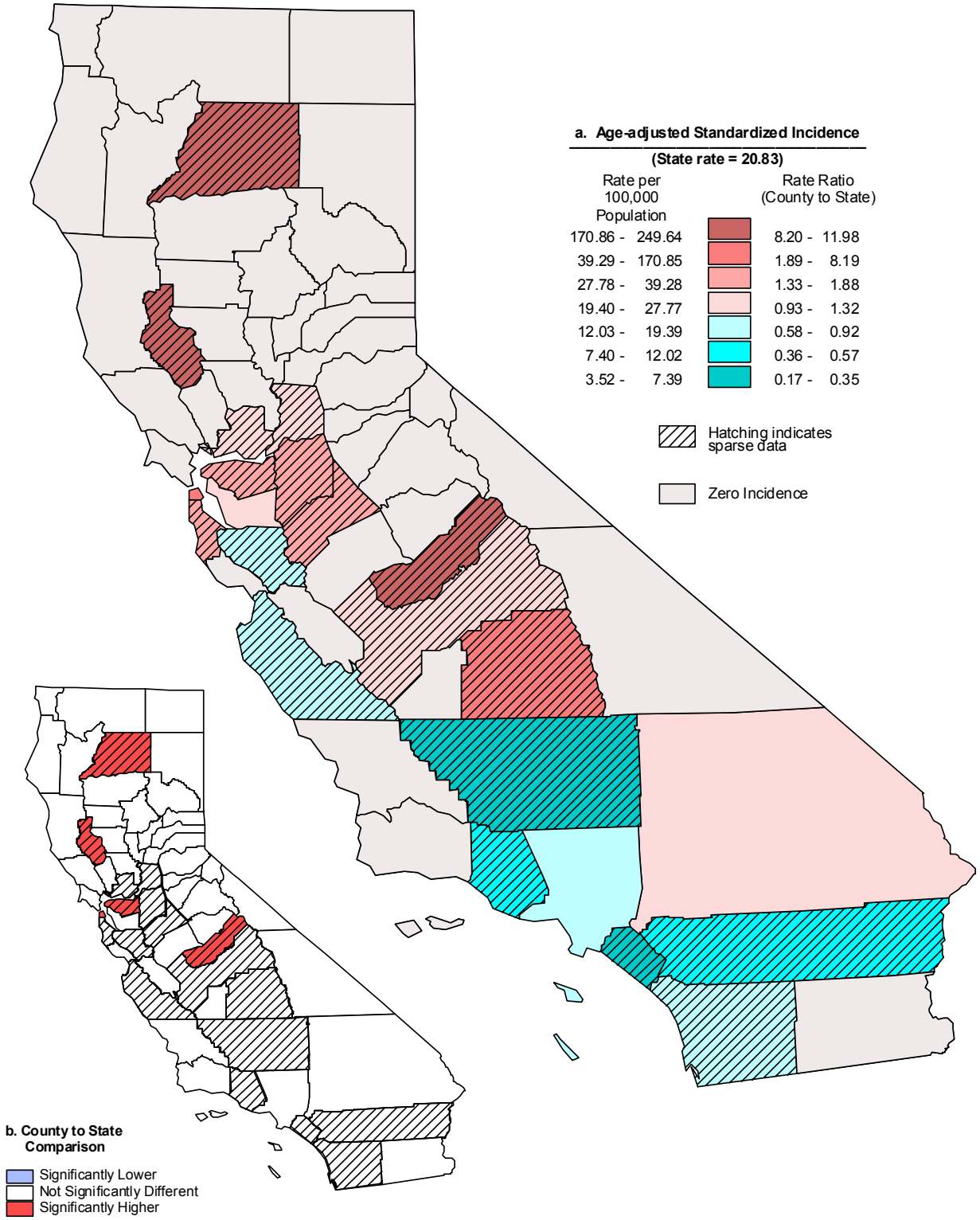
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There was one county with a reliable incidence rate that had a significantly higher rate compared to the State rate (Figure 6b). The one county was San Francisco (RR = 2.95).

Figure 6. Incidence Rates by County, 1998

AIDS
Black (non Hispanic) Female



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

Hispanic Females

The California age-adjusted standardized incidence rate for Hispanic females was 3.63 per 100,000 population (population size = 4,687,792). The county-level incidence rates among Hispanic females ranged from 0.00 to 21.81 per 100,000 population (Figure 7a). Table 6 presents the five counties with the highest AIDS incidence rates.

Table 6. Highest county-specific incidence rates for Hispanic females

County	Rate (per/100,000)	Population
Napa*	21.81	9,071
San Francisco*	10.28	58,114
Yolo*	5.96	17,785
Tulare*	5.79	75,241
San Diego*	5.79	325,542

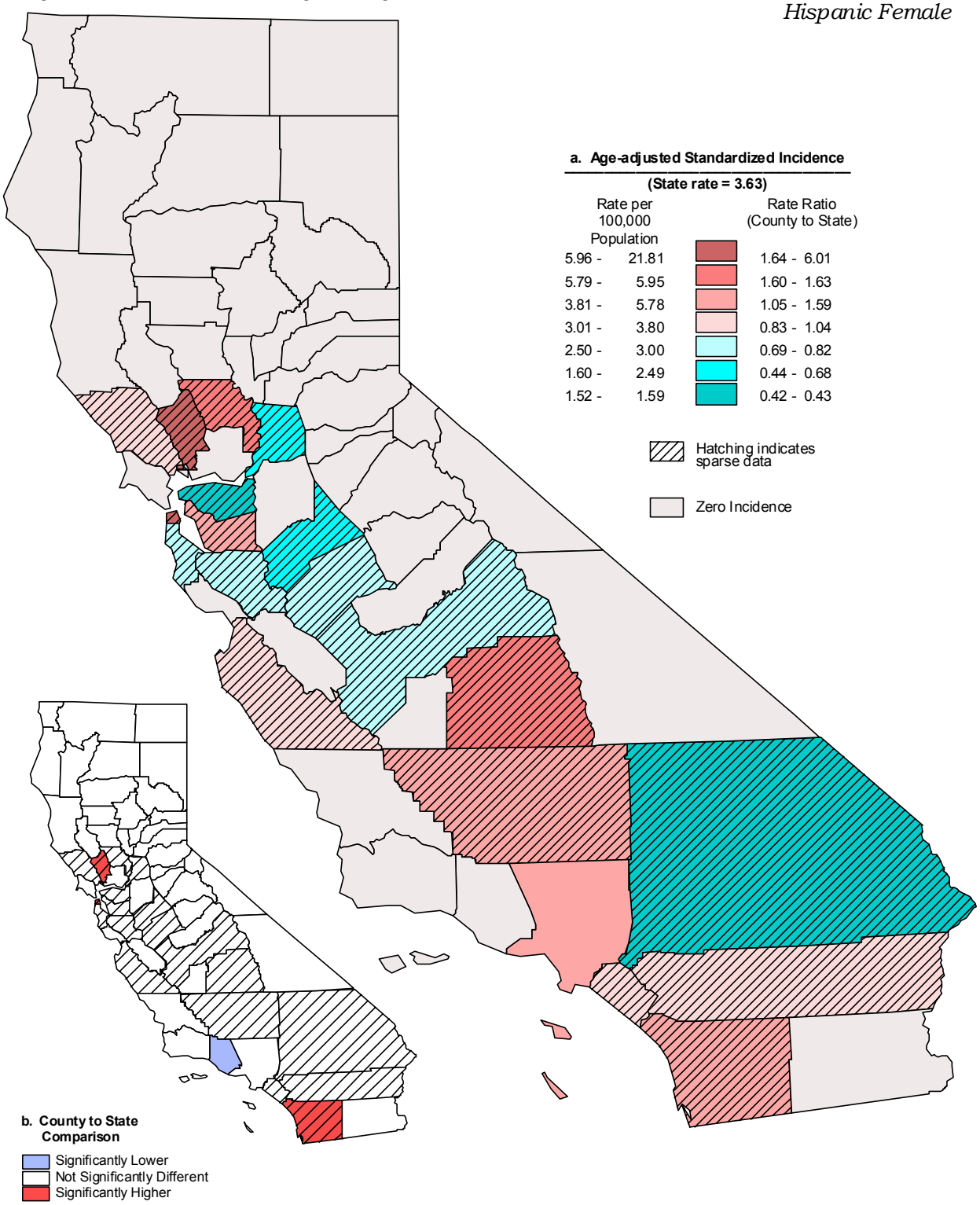
Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

**Unreliable rates due to large coefficient of variation*

There were no counties with reliable incidence rates that had significantly higher rates compared to the state rate (Figure 7b).

Figure 7. Incidence Rates by County, 1998

AIDS
Hispanic Female



Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Office of AIDS, 2001

Gender and Race/Ethnicity Comparison

Table 7 presents the age and race/ethnicity-specific age-adjusted standardized AIDS incidence rates. Black (non-Hispanic) males had the highest statewide incidence rates (83.38 per 100,000). The rate for Black (non-Hispanic) males was 4.2 times higher than for White (non-Hispanic) males, about three times higher than for Hispanic males, and four times higher than for Black (non-Hispanic) females. The rate among Black (non-Hispanic) females was slightly higher than the rate among White (non-Hispanic) males. Among females, Black (non-Hispanic) females had the highest rate. Their rate was 12.6 times higher than for White (non-Hispanic) females and 5.7 times higher than for Hispanic females.

Black (non-Hispanic) males in Kings county, Black (non-Hispanic), White (non-Hispanic), and Hispanic males in San Francisco county, and White (non-Hispanic) males in Marin county had the highest reliable* incidence rates and the highest rank (upper 10%) in California (Table 8).

Table 9 presents the list of counties with reliable incidence rates significantly higher than statewide rate. The incidence rate of White (non-Hispanic) males in San Francisco compared to all White (non-Hispanic) males in the State was the highest (RR = 11.03).

***** Estimated incidence rates with coefficients of variation less than 0.23 were considered reliable.

Table 7. Gender and Race/Ethnicity-Specific Age-Adjusted Standardized Incidence Rates of AIDS in California, 1998.

Gender & Race/Ethnicity	State Rate (Per/100,000)	Population
Black (non-Hispanic) males	83.38	1,217,344
Hispanic males	27.53	5,023,544
Black (non-Hispanic) females	20.83	1,233,786
White (non-Hispanic) males	20.09	12,824,406
Hispanic females	3.63	4,687,792
White (non-Hispanic) females	1.65	12,768,001

Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

Table 8. Reliable* Gender and Race/Ethnicity-Specific Age-Adjusted Standardized Incidence Rates for Counties with Highest Rank (upper 10%)

County	Gender & Race/Ethnicity	Rate (per/100,000)
Kings	Black (non-Hispanic) males	369.00
San Francisco	Black (non-Hispanic) males	270.04
San Francisco	White (non-Hispanic) males	221.72
San Francisco	Hispanic males	122.21
Marin	White (non-Hispanic) males	34.60

Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

** Estimated incidence rates with coefficients of variation less than 0.23 were considered reliable.*

Table 9. Incidence Rate Ratios for All Counties with Reliable Age-Adjusted Standardized Incidence Rates that are Statistically* Higher Compared to the State Rate

County	Gender & Race/Ethnicity	Rate Ratio
San Francisco	White (non-Hispanic) males	11.03
San Francisco	Hispanic males	4.44
Kings	Black (non-Hispanic) males	4.43
San Francisco	Black (non-Hispanic) males	3.24
San Francisco	Black (non-Hispanic) females	2.95
Marin	White (non-Hispanic) males	1.72
Riverside	White (non-Hispanic) males	1.62
Kern	Black (non-Hispanic) males	1.57
Solano	White (non-Hispanic) males	1.54
San Diego	Hispanic males	1.33
San Diego	White (non-Hispanic) males	1.28
Los Angeles	Hispanic males	1.28

Source: 1998 HIV/AIDS Case Registry, California Department of Health Services

* α=.05

DISCUSSION

This report utilizes statistical and GIS methodologies to present public health officials, policy makers and researchers with a unique tool to examine 1998 demographic subgroup specific AIDS incidence rates in California. Gender and race/ethnicity specific AIDS incidence rates vary dramatically in California. In order to assess these differences, we calculated separate incidence rates for each gender and race/ethnicity subgroup.

Additionally, there are large geographic variations in AIDS incidence rates within each demographic subgroup. This variation indicates a further need for separate incidence rates specific to each California county. These many rates, while extremely valuable unto themselves, do not fully convey the spatial distribution of the AIDS epidemic in California. Maps of AIDS incidence for each gender/race/ethnicity subgroup facilitate a true understanding of the geography of the AIDS epidemic in California.

Age-adjusted incidence rates were calculated for six demographic subgroups using the 1998 California population as a standardization reference. Adjustment by age was conducted to give a more realistic picture of incidence than crude rates would provide. As statewide-adjusted rates show, Black (non-Hispanic) males show disproportionately high AIDS incidence rates compared to other demographic subgroups. Hispanic males and Black females followed Black males in highest statewide incidence rates. The demographic breakdown of these three highest incidence rate groups should be an important consideration in evaluating whether HIV/AIDS prevention and treatment programs have been effective in all segments of the population.

County-specific AIDS incidence rates are necessary to understand how incidence rates vary geographically within each demographic subgroup. As can be seen, the counties with highest incidence rates for several of the demographic subgroups are not necessarily associated with the major metropolitan areas of California. Higher than expected incidence rates in non-metropolitan areas may be attributable to AIDS incidence in incarcerated populations. Our results indicate that traditional perceptions of high risk areas must be reevaluated when considering prevention and treatment options for the 20-year California AIDS epidemic.

Maps of county specific AIDS incidence rates were created for each demographic subgroup using a GIS. These maps convey information about current incidence rates for each county far more easily than the raw numbers, and additionally convey a sense of the spatial distribution of the epidemic. Major metropolitan areas continue to have high incidence rates, but this phenomenon is no longer isolated to the cities. Many primarily rural counties in central and northern California have surprisingly high incidence rates for

multiple demographic subgroups. This information should provide a reminder to many in California that HIV/AIDS knows no boundaries. Additionally, maps of statistical comparisons to statewide incidence rates further illustrate the geographic variability between counties for specific demographic subgroup populations.

Limitations of this study include the use of 1998 AIDS incidence data, and the population-based nature of the study. This study is a population-based or *ecological* study. Causal interpretation of specific etiologies in population based studies is often difficult when compared to interpretations in individual level studies. However, population level studies are often the only analytical method available, and can generate initial leads and hypotheses to be further tested in individual level studies.

AIDS incidence in California is an ongoing challenge to be solved. A correct understanding of the epidemic is vital in order to effectively target specific high risk groups with education and prevention programs, and for the efficacious treatment of persons living with AIDS. This report provides public health officials, policy makers, and researchers with a unique tool to examine AIDS incidence rates in major demographic subgroups. The maps and tables presented here can facilitate understanding of the California AIDS epidemic, and provide a concrete framework on which educated decisions may be made.

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Appendix 1. California Counties

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