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Causes of death among individuals with systemic lupus erythematosus by race and ethnicity: a population-based study

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Abstract

Objective.—Non-white populations are at higher risk of developing systemic lupus erythematosus (SLE) and have more severe outcomes, including mortality. How specific causes of death vary by race and ethnicity has largely been unexplored, particularly for Asian and Hispanic individuals.

Methods.—The California Lupus Surveillance Project included SLE cases identified among residents of San Francisco County, CA during January 1, 2007–December 31, 2009. Cases were matched to the National Death Index over a ten-year period. Logistic regression examined age-adjusted differences in causes of death by race, ethnicity, and sex. Age-standardized mortality ratios (SMRs) between individuals with SLE and the corresponding general population were calculated for the leading cause of death, and observed versus expected deaths were estimated.

Results.—The study included 812 individuals of White (38%), Asian (36%), Black (20%), and mixed/other/unknown (5%) race; 15% identified as Hispanic. 135 deaths were recorded, with mean age at death of 62.2 (+/− 15.6) years. Cardiovascular disease (CVD) was the leading cause of death overall (33%), and across all racial and ethnic groups, followed by rheumatic disease (18%) and hematological/oncological conditions (18%). CVD as the underlying cause of death was 3.63 times higher among SLE cases than in the general population. CVD deaths for those with SLE were nearly four and six times higher for Asian and Hispanic individuals with SLE, respectively, compared to the general population.

Conclusion.—Individuals with SLE experience a disproportionate burden of CVD mortality compared to the general population, which is magnified for Asian and Hispanic groups.

Systemic lupus erythematosus (SLE) is a chronic autoimmune disease that can lead to severe clinical outcomes, with patients having higher rates of mortality when compared to the general population (1–4). Despite improving trends in mortality, with the SLE mortality rate decreasing 2.7% every year from 1999 through 2013, overall mortality rates from SLE

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remain high (5). For example, previous population-based studies have shown that individuals with SLE are three times more likely to die over a ten-year period than age-matched individuals in the general population (1–2).

Recent work has also demonstrated that disparities in SLE mortality persist according to sex, race, ethnicity, age, and geographic region (5). SLE as a leading causes of death in young women is consistently ranked higher among non-white women (6). Mortality among hospitalized patients with SLE has been shown to be higher for Asian, Hispanic, and Black individuals compared to White individuals (7). Population-based studies have also found that Black females with SLE are two to three times more likely to die over a ten-year period than Black females in the general population (1–2), and Asian and Hispanic individuals with SLE are nearly four times more likely to die over a ten-year period than their counterparts in the general population (2). While this research underscores the burden of mortality in non-white individuals with SLE, there is a paucity of contemporary data exploring the contributing factors to mortality, such as specific causes of death, in the SLE population, and whether they differ by demographic factors.

We sought to determine the top causes of death among individuals with SLE in the California Lupus Surveillance Project using National Death Index (NDI) records over a ten-year period and examine whether the top causes of death varied by race, ethnicity, and sex. Finally, we measured whether mortality of the leading cause of death differed in the SLE population compared to the general population.

PATIENTS AND METHODS

Study Population

The study population included individuals with SLE from the California Lupus Surveillance Project (CLSP). Individuals with SLE were identified among residents of San Francisco County, California during January 1, 2007–December 31, 2009 using community rheumatology and nephrology clinics, community hospitals, and integrated health care systems (8,9). Individuals were not contacted for this linkage study. The following International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) diagnostic codes were used: 710.0 (SLE), 695.4 (lupus erythematosus, discoid lupus, or other local lupus), 710.8 (other specified diffuse connective tissue disease), and 710.9 (unspecified diffuse connective tissue disease). Individuals with SLE were also identified though a commercial laboratory, which was queried for a comprehensive panel of SLE-related serologic tests and the California Office of Statewide Health Planning and Development hospital discharge database (8). A waiver was granted for this public health surveillance study by the State of California Institutional Review Board. The project was also reviewed and approved by the University of California, San Francisco, Institutional Review Board and the CDC, and was conducted in accordance with applicable federal law and CDC policy.

Diagnoses of SLE were defined using either the American College of Rheumatology (ACR) classification criteria (at least 4 of the 11 revised criteria as defined in 1982 and updated in 1997) (10,11), or two alternative definitions: SLE diagnosed by the patient’s

treating rheumatologist plus three ACR criteria or lupus-related kidney disease (World Health Organization class II–VI lupus nephritis upon biopsy or documented record of SLE diagnosis and dialysis or renal transplantation). All individuals in CLSP with sufficient information (812/909, 89%) were submitted to the NDI (2007–2017) to search for potential matches (general sensitivity of 87.0%–97.9% and specificity of approximately 100%) (12). Matching required at least one of the following data items or combinations: first and last name and social security number; first and last name and month and year of birth; or social security number full date of birth, and sex; otherwise, the case was excluded from analyses. Individuals were considered a match based on provided information including social security number, except for one case in which the social security number was not included in the NDI record but was considered a match through first and last name, month and year of birth, and state where death took place.

Exposure

Race, ethnicity, and sex were collected for individuals in the study. Of note, Hispanic ethnicity is considered a distinct concept from race, therefore it was collected and reported separately from race. The intercensal database of the Census Bureau codes race and Hispanic ethnicity using two variables; one collapses all persons into four mutually exclusive categories defined by bridged race, without accounting for Hispanic ethnicity: Black, White, Asian/Pacific Islander, and American Indian/Alaska Native (13). The other codes Hispanic ethnicity as a separate construct. Consistent with prior analyses using California Lupus Surveillance Project data (2,8), race and ethnicity were considered separate variables in statistical analyses; therefore, persons in the ethnicity category are also represented in the race categories.

Outcome

Cause of death reports for this study were provided by the NDI as ICD-10 codes. An “underlying cause of death” is indicated on the reports, as well as “any cause of death” fields, each of which can contain up to 20 cause of death codes. The underlying cause of death is defined as “(a) the disease or injury which initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury” (14). As described in the NDI User’s Guide, the underlying cause of each death is selected from an array of conditions reported in the medical certification section on the death certificate. The rules for selecting the underlying cause of death are included in ICD as a means of standardizing classification, which contributes toward comparability and uniformity in mortality medical statistics among countries (15). For “any cause of death” analyses, record-axis codes were utilized. Record-axis codes are a set of ICD codes that best describe the overall medical certification portion of the death certificate, based on an algorithmic process (16). ICD-10 codes for “underlying” and “any” cause of death were then categorized into groups based on organ system and disease according to a previous study examining in-hospital mortality in adult SLE (17).

Statistical Analysis

Fisher’s exact tests were used to examine unadjusted differences in underlying and any cause of death by race (White, Black, Asian), ethnicity (Hispanic, non-Hispanic), and sex

(female, male). We also conducted logistic regression to examine age-adjusted differences in underlying and any cause of death by race, ethnicity, and sex; when cell sizes contained zero, the Fisher's exact unadjusted p-value is reported. In secondary analyses, we calculated the corresponding expected number of deaths in San Francisco County attributed to the leading cause of death found in our study population. Population estimates by age group, sex, race, and Hispanic ethnicity for San Francisco County for 2007–2017 were obtained from CDC Wonder (18) and used to calculate standardized mortality ratios (SMRs) of observed-to-expected deaths among persons with SLE using indirect age-standardization in 11 age groups, as the ratio of observed deaths among persons with SLE to expected deaths in the San Francisco County population. Expected deaths were calculated by multiplying the age-specific death rate of the general population in San Francisco County by the total number of individuals with SLE in each age group for race, ethnicity, and sex comparisons. Three individuals were excluded from SMR analyses, as rates from CDC Wonder were not available for ages < 15 years. Two-sided hypothesis tests were conducted controlling the type I error rate at 5% (alpha = 0.05) and estimated 95% confidence intervals. Stata (version 16.0; Stata Corp) was used to conduct all analyses.

RESULTS

Demographic characteristics of the 812 individuals with SLE included in the study are shown in Table 1. The majority of individuals were in the age range 10–34 years (25%), followed by 45–54 years (23%) during the ascertainment window of the surveillance study. Women constituted approximately 90% of the study population; and race and ethnicity included White (38%), Asian (36%), Black (20%), mixed/other race (3%), and unknown (2%). Fifteen percent of individuals identified as Hispanic.

There were 135 deaths (16.6%) identified during the ten-year period. The mean age at death was 62.2 (+/−15.6) years. Black individuals with SLE had the highest mortality (25%), followed by Asian (15%), White (14%), and other race (9%) individuals. With respect to ethnicity, non-Hispanic individuals with SLE experienced higher mortality compared to Hispanic individuals with SLE, at 18.5% and 15.5%, respectively. Men (19.8%) with SLE also had a higher mortality than women with SLE (16.3%).

Underlying Cause of Death

Underlying causes of death by race, ethnicity, and sex are shown in Table 2. The top underlying cause of death among individuals with SLE was cardiovascular disease (33%). This was also the top underlying cause of death among Black (39%), Asian (32%), and White (28%) individuals, as well as Hispanic (37%) and non-Hispanic (32%) individuals. When examining differences in top underlying causes of death by race, ethnicity, and sex, we found that males were more likely to have rheumatic disease listed as an underlying cause of death (38%) than females (15%) (p=0.03). Additionally, genitourinary diseases were more likely to be the underlying of death among Hispanic individuals with SLE (11%) compared to non-Hispanic individuals with SLE (1%) (p=0.01). No other statistically significant differences were found.

In a multivariable model examining the top underlying cause of death (cardiovascular disease [CVD]) adjusted for age, sex, race, and ethnicity, we found that odds were not significantly higher for Asian (OR=1.90; 95%CI: 0.70, 5.12) and Black (OR=1.29; 95% CI: 0.49, 3.38) individuals with SLE compared to White individuals with SLE (Table 3). Similarly, the adjusted odds of CVD as the underlying cause of death did not differ by ethnicity or sex.

Any Cause of Death

Across any causes of death, CVD was the most common among all individuals with SLE (56%), as well as for Asian (61%), Black (59%), non-Hispanic (57%), and Hispanic (53%) individuals (Supplementary Table 1). Among White individuals, the most common cause of death was rheumatic disease (50%), in comparison to Asian (46%) and Black (27%) individuals with SLE; however, this difference was not statistically significant (p=0.48). Further, there were no differences in any cause of death among SLE patients by ethnicity or sex. A multivariable model examining the top any cause of death (CVD) adjusted for age, sex, race, and ethnicity demonstrated consistent findings as the underlying cause of death analysis (data not shown).

Standardized Mortality Ratios

In secondary analyses, we explored whether differences in the overall leading cause of death, CVD, differed in the SLE population compared to the general San Francisco County population during the same period (2007–2017) (Table 4). Using SMRs, we found that CVD as the underlying cause of death was over three times higher in the SLE population compared to the general San Francisco population (SMR=3.63, 95% CI 2.65, 4.86), with the largest difference found among Asian race individuals (SMR=3.83, 95% CI 2.09, 6.42). Additionally, Hispanic individuals with SLE were over six times more likely to die of CVD than Hispanic individuals in the general population (SMR=6.45, 95% CI 2.59, 13.29). Females with SLE were also over four times more likely than females in the general San Francisco County population to experience CVD as the underlying cause of death (SMR=4.65, 95% CI 3.32, 6.34). Across all other groups, those with SLE were consistently two to three times more likely to die of CVD than the corresponding general population. Findings remained consistent when examining CVD as any cause of death (Supplementary Table 2).

DISCUSSION

This is the first study to comprehensively assess causes of death in individuals with SLE by race, ethnicity, and sex, including Asian and Hispanic individuals, using a population-based sample in the U.S. With a racially and ethnically diverse dataset merged with records from the National Death Index spanning ten years, we found that the top five underlying causes of death among individuals with SLE were cardiovascular, rheumatic, hematology/oncology, gastrointestinal, and respiratory diseases. We did not find any statistical differences in underlying or any causes of death by race or ethnicity, except among genitourinary disease, where Hispanic individuals with SLE were more likely to have this listed as an underlying cause of death compared to non-Hispanic individuals with SLE (11% vs. 1%, respectively).

However, this difference could be due to chance, given the small absolute number of individuals in each group. Codes within this category included two related to chronic kidney disease, and one related to urinary tract infection. Important to note, codes relating to lupus nephritis could also be categorized under “rheumatologic” disease (e.g. “glomerular disease in SLE”).

Among individuals with SLE, odds of death by CVD did not differ by sex, race, or ethnicity. Overall, those with SLE were nearly four times more likely to experience CVD as the underlying cause of death compared to the general population. Estimates were particularly elevated for Asian and Hispanic individuals with SLE, who were approximately four and six times more likely to die of CVD compared to the general population.

Although several studies have determined that individuals with SLE experience higher mortality than the general population (1,2), less is known about the causes contributing to death. Similar to prior research (17,19,20), this study found CVD to be among the top causes of mortality among individuals with SLE. CVD risk in individuals with SLE is not fully explained by traditional risk factors (21). Atherosclerosis develops at younger ages in individuals with SLE, and those with lupus nephritis demonstrate even higher risk of CVD outcomes, given increased rates of hypertension, hyperlipidemia, and use of glucocorticoids (22–24). The pathogenesis of premature vascular damage in the SLE population is still unknown, but thought to involve not only traditional cardiovascular risk factors, but also chronic inflammation, endothelial dysfunction, and cytokines such as type I interferons leading to abnormal vascular repair (25).

Manadan et al. used data from the National Inpatient Sample and found that infections accounted for 37% of deaths, followed by CVD (21%) (17). Among our population-based study of individuals with SLE, CVD was listed as the underlying cause of death for 33% of individuals, followed by rheumatic disease (18%); infections represented only 2% of deaths. Differences in findings with respect to infections are likely due to severe infections being overrepresented within the hospitalized population in previous studies; additionally, the National Inpatient Sample (NIS) does not provide data on an individual level, and therefore may include repeated hospitalizations for infections in certain individuals. Similarly, the NIS does not include some of the additional information captured on death certificate data.

A study published in 1995 by Ward et al. found the leading causes of death among SLE patients to be SLE itself (34%), infection (22%), and cardiovascular disease (16%) (26). Although treatment paradigms, and therefore causes of mortality, have changed considerably since that time, the study was comparable to ours with respect to follow-up time. Deaths were assessed more comprehensively by Ward et al., including detailed review of clinical records in addition to death certificates. Further, the average age at death was 48.3 years, while our population’s average age at death was 62.2 years. It has been shown that causes of death in SLE can vary with the duration of SLE disease, with SLE being the most common cause of death in younger individuals (19–22 year olds) (26–29). Since we identified a prevalent cohort of individuals with SLE, rather than an inception cohort, and our cohort reflects more contemporary treatment paradigms for SLE, differences in causes of death recorded are expected.

Few studies have previously examined causes of death by race or ethnicity in the SLE population. Unlike the results in our study, Ward et al. found differences in the leading causes of death between White and Black individuals (26); the leading causes of death among Black individuals with SLE were SLE itself (39%) and infection (36%), while our results showed that cardiovascular disease (39%) and hematologic/oncologic conditions (17%) were the leading causes. Again, these differences likely reflect advances in treatment options for inflammatory manifestations related to SLE over the last 25 years, including lupus nephritis. We did not find any significant differences in underlying or any causes of death by race or ethnicity; however, due to small numbers of deaths, our analyses could have been underpowered. In agreement with Ward et al., we found no differences in "any" causes of death between males and females; however, we did find a significantly higher percentage of males having a diagnosis within the rheumatologic category as the underlying cause of death compared to females (38% vs 15%, respectively).

Interestingly, we found that only 41% of individuals in our study population had a rheumatologic condition listed as "any" cause of death on their death certificate. These findings mirror a study by Falasinnu et al. which found that among a cohort of Swedish individuals with SLE, only 41% of over 1800 deaths had SLE listed as a cause of death on their death record (30). Older patients were less likely to have SLE listed as a cause of death, indicating that there may be an underestimation of the true burden of disease in older patients, a group more likely to have clinically quiescent disease. Similarly, a study from France found that individuals with SLE that were under 40 years of age were more likely to have SLE coded as an underlying cause of death; researchers in that study found that SLE was listed as any cause of death in 60% of patients (31). Therefore, previous studies examining SLE as a cause of death (6) may be substantially underestimating the burden in various populations.

Our findings also suggest that there are substantial health disparities in the burden of CVD death among individuals with SLE. Asian and Hispanic individuals with SLE were four to six times more likely to experience CVD as their underlying cause of death than their counterparts in the general population. One meta-analysis found that compared to the general population, the risk of CVD in individuals with SLE increased by two times (32). This risk includes a higher risk of atherosclerosis, stroke, myocardial infarction, peripheral vascular disease, and heart failure (32). Less is known regarding how CVD mortality in SLE varies by race and ethnicity, although some studies have indicated higher rates of certain CVD events in Black and Hispanic individuals with SLE as compared to White individuals with SLE (33). Barbhaiya et al. also found lower risk of CVD rates and MI events among Asian individuals with SLE compared to white individuals with SLE, although this finding may be due to differences in the individuals included in the study (i.e. SF county population-based vs. Medicaid eligible) and varied risks among Asian subgroups. Our results demonstrated that compared to the general population of individuals in San Francisco, SMRs of CVD as the underlying cause of death were highest among Asian and Hispanic individuals with SLE. The larger magnitudes of effect could be due to lower baseline rates of CVD in Asian and Hispanic individuals in the U.S. (34), or greater disease severity in Asian and Hispanic individuals with SLE (35). More research is needed to understand the mortality disparities found in our study, and determine how they may

relate to access to care, treatment effectiveness, and social determinants of health in order to improve health in vulnerable populations. Targeted outreach and aggressive disease control in these populations is also warranted.

Strengths of this study include the ability to examine causes of death by race and ethnicity among White, Black, Asian, and Hispanic populations in a population-based sample of individuals with SLE. Further, we utilized national records and death certificates to ascertain mortality and causes of death over a ten-year span. We were also able to compare rates for specific causes of death in individuals with SLE to the general population of San Francisco County adjusted for age, race, and ethnicity during the same period.

Limitations of the study include that the multiple cause of death analysis is based on the accuracy of information presented on death certificates, for which processes vary from state to state. Underlying cause of death was identified via the NDI, which notates a singular underlying cause of death in addition to other demographic data available (15). To validate the underlying cause of death for individuals within our study population, ICD codes listed on the death certificates for a random set of 10 patients were examined by a rheumatologist (CA). The review identified 2/10 instances where the underlying cause of death was potentially incorrectly coded based on the collection of ICD codes listed. Additionally, we were able to access medical records for two different patients who died in the cohort. Detailed chart review by the same reviewer (CA) found that for one of the two patients, the underlying cause of death listed on the death certificate differed from the cause of death listed in the medical record. Given these findings, future work is needed to assess the validity of the NDI algorithm among certain disease populations, such as SLE. Our limited chart review was not designed as a full validation study and the small sample size precludes conclusions about error rates. In the general population, NDI-derived CVD mortality had sensitivity 73.4%, specificity 84.5%, positive predictive value 70.6%, and negative predictive value 86.2% (36). We think it is reasonable to assume that these numbers apply to our sample, which increases our confidence in the findings. Finally, our findings may not be generalizable outside of San Francisco County.

There is a timely and critical need to gain a more holistic understanding of the interconnections between racial and ethnic health disparities and main causes of death among individuals with SLE in the U.S. While studies have examined the top causes of death among individuals with SLE, or racial disparities in various health outcomes, there is a lack of contemporary studies that examine the top causes of death by race and ethnicity among individuals with SLE in the U.S., and virtually none within the Asian-American SLE population. Hispanic and Asian individuals currently comprise 19% and 6% of the US population and those figures are estimated to increase to 26% and 8% by the year 2050 (37); thus, reliable estimates of the burden of SLE are essential for future health care planning. Studying how various causes of death contribute to mortality rates in SLE by race and ethnicity will help deepen our understanding of disparities in SLE outcomes in the U.S. and assist in creating targeted interventions to reduce mortality in at-risk populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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SIGNIFICANCE AND INNOVATIONS

- Contemporary data exploring the contributing factors to mortality in the SLE population, such as specific causes of death and whether they differ by demographics, is limited.
- Using a large, diverse population-based study of individuals with SLE, this study found that cardiovascular disease (CVD) was the leading cause of death overall, and across all racial and ethnic groups, followed by rheumatic disease and hematological/oncological conditions.
- CVD as the underlying cause of death was nearly four times higher among SLE cases than in the general population. CVD deaths for those with SLE were nearly four and six times higher for Asian and Hispanic individuals with SLE, respectively, compared to the general population.
- Studying how various causes of death contribute to mortality rates in SLE by race and ethnicity help deepen our understanding of disparities in SLE outcomes among non-white populations in the U.S., and assist in creating targeted interventions to reduce mortality in this population.

Table 1.

Mortality among cases of systemic lupus erythematosus (SLE) for 2007–2017—California Lupus Surveillance Project*

Characteristic	No. Deaths / No. SLE Cases	% Mortality
Overall	135/812	16.6
Sex		
Female	119/731	16.3
Male	16/81	19.8
Age group (years)		
10–34	11/204	5.4
35–44	15/175	8.6
45–54	26/185	14.1
55–64	33/153	21.6
65–74	35/70	50.0
75+	15/25	60.0
Race		
White	45/312	14.4
Asian	45/295	15.3
Black	41/164	25.0
Other	<10/22	9.1
Ethnicity§		
Non-Hispanic/Latino	112/604	18.5
Hispanic/Latino	19/123	15.5

CI = Confidence Interval

*Nineteen cases were missing race information, including two who died, and 85 cases were missing Hispanic/Latino ethnicity status, including four who died.

§Hispanic/Latino ethnicity is considered a distinct concept from race, therefore it was collected and reported separately from race.

Table 2.

Underlying causes of death among patients with systemic lupus erythematosus by race, ethnicity, and sex

		Race[#]				Ethnicity[†]			Sex		
Organ System/ Disease Categories and ICD-10 Codes [§]	**Total N=135**	**White N=46**	**Black N=41**	**Asian N=44**	**P-value[‡]**	**Hispanic N=19**	**Non-Hispanic N= 112**	**P-value[‡]**	**Female N=119**	**Male N= 16**	**P-value[‡]**
Cardiovascular I00-I99	45 (33%)	13 (28%)	16 (39%)	14 (32%)	0.66	<10 (37%)	36 (32%)	0.53	40 (34%)	<10 (31%)	0.85
Rheumatologic M00-M99	24 (18%)	12 (26%)	<10 (12%)	<10 (14%)	0.07	<10 (32%)	18 (16%)	0.29	18 (15%)	<10 (38%)	0.03
Hematology / Oncology C00-D49	24 (18%)	<10 (17%)	<10 (17%)	<10 (20%)	0.64	<10 (5%)	23 (21%)	0.20	22 (18%)	<10 (13%)	0.56
Gastrointestinal K00-K95	<10 (6%)	<10 (7%)	<10 (2%)	<10 (9%)	0.63	<10 (5%)	<10 (4%)	0.85	<10 (5%)	<10 (13%)	0.25
Respiratory J00-J99	<10 (5%)	<10 (2%)	<10 (7%)	<10 (7%)	0.32	0 (0%)	<10 (6%)	0.59[*]	<10 (6%)	0 (0%)	1.00[*]
Infectious A00-B99	<10 (2%)	<10 (2%)	<10 (2%)	<10 (2%)	0.98	0 (0%)	<10 (3%)	1.00[*]	<10 (3%)	0 (0%)	1.00[*]
Endocrine E00-E89	<10 (2%)	<10 (2%)	<10 (2%)	<10 (2%)	0.99	0 (0%)	<10 (3%)	1.00[*]	<10 (3%)	0 (0%)	1.00[*]
Psychiatry F01-F99	<10 (2%)	<10 (2%)	<10 (5%)	0 (0%)	0.54	0 (0%)	<10 (3%)	1.00[*]	<10 (2%)	<10 (6%)	0.27
Neurologic G00-G99	<10 (2%)	0 (0%)	0 (0%)	<10 (7%)	0.13	0 (0%)	<10 (3%)	1.00[*]	<10 (3%)	0 (0%)	1.00[*]
Genitourinary N00-N99	<10 (2%)	<10 (4%)	0 (0%)	<10 (2%)	0.53	<10 (11%)	<10 (1%)	0.03	<10 (3%)	0 (0%)	1.00[*]
Other R00-R99	<10 (2%)	<10 (2%)	<10 (2%)	0 (0%)	0.43	<10 (5%)	<10 (2%)	0.45	<10 (3%)	0 (0%)	1.00[*]
Accidents V00-Y99	<10 (1%)	<10 (2%)	<10 (2%)	0 (0%)	0.31	0 (0%)	<10 (2%)	1.00[*]	<10 (2%)	0 (0%)	1.00[*]

[#] 2 deaths with missing race and 2 deaths with "other" race were excluded from race-specific columns.

[†] 4 deaths without ethnicity documented were excluded from ethnicity-specific columns.

[§] Zero cell counts across all columns for the following categories: eye/ear (H00-H95), skin (L00-L99), obstetrics (O00-O9A), perinatal (P00-P96), congenital (Q00-Q99), injury/poison (S00-T88), health services (Z00-Z99)

[‡] P-value from age-adjusted logistic regression models assessing differences between racial groups (White, Black, Asian), ethnicity (Hispanic, non-Hispanic), or sex (female, male)

[*] P-value represents Fisher's exact test (unadjusted for age), as cell sizes include 0.

Table 3.

Logistic regression model examining characteristics associated with cardiovascular disease as the underlying cause of death in individuals with SLE

Characteristic	OR (95% CI)	P-value
Age	1.02 (0.99, 1.04)	0.23
Race		
White	*Ref*	--
Asian	1.90 (0.70, 5.12)	0.21
Black	1.29 (0.49, 3.38)	0.61
Ethnicity		
Non-Hispanic	*Ref*	--
Hispanic	1.49 (0.42, 5.30)	0.54
Sex		
Male	*Ref*	--
Female	1.25 (0.37, 4.26)	0.72

Table 4.

Standardized mortality ratios of cardiovascular disease (CVD) as the underlying cause of death in SLE patients compared to the general San Francisco County population, age-standardized, 2007–2017

		CVD as Underlying Cause of Death		
Characteristic	**Total SLE Population[#]**	**Observed CVD Deaths**	**Expected CVD Deaths[*]**	**SMR (95% CI)**
Overall	809	45	12.4	3.63 (2.65, 4.86)
Race[^]				
White	311	13	5.3	2.43 (1.29, 4.16)
Asian	294	14	3.7	3.83 (2.09, 6.42)
Black	164	16	5.5	2.89 (1.65, 4.70)
Ethnicity[†]				
Hispanic	123	<10	1.1	6.45 (2.59, 13.29)
Non-Hispanic	604	36	10.6	3.39 (2.37, 4.69)
Sex				
Female	728	40	8.6	4.65 (3.32, 6.34)
Male	81	<10	1.4	3.48 (1.13, 8.12)

[#]Three patients excluded from SMR analyses, as rates from CDC Wonder were not available for ages < 15 years.

[*]Expected rate calculated from age-specific crude mortality rates from cardiovascular disease in San Francisco County

[^]2 deaths with missing race and 2 deaths with “other” race were excluded from race-specific columns.

[†]4 deaths without ethnicity documented were excluded from ethnicity-specific columns.