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Disparities in survival after Hodgkin lymphoma: a population-based study

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Abstract

Survival after Hodgkin lymphoma (HL) is generally favorable, but may vary by patient demographic characteristics. The authors examined HL survival according to race/ethnicity and neighborhood socioeconomic status (SES), determined from residential census block group at diagnosis. For 12,492 classical HL patients ≥15 years diagnosed in California during 1988-2006 and followed through 2007, we determined risk of overall and HL-specific death using Cox proportional hazards regression; analyses were stratified by age and Ann Arbor stage. Irrespective of disease stage, patients with lower neighborhood SES had worse overall and HL-specific survival than patients with higher SES. Patients with the lowest quintile of neighborhood SES had a 64% (patients aged 15-44 years) and 36% (≥45 years) increased risk of HL-death compared to patients with the highest quintile of SES; SES results were similar for overall survival. Even after adjustment for neighborhood SES, blacks and Hispanics had increased risks of HL-death 74% and 43% (15-44 years) and 40% and 17% (≥45 years), respectively, higher than white patients. The racial/ethnic differences in survival were evident for all stages of disease. These data provide evidence for substantial, and probably remediable, racial/ethnic and neighborhood SES disparities in HL outcomes.

Keywords

Hodgkin disease; survival; mortality; social class; census

INTRODUCTION

Over half of Hodgkin lymphomas (HL) diagnosed in the United States (US) occur in persons under 35 years of age, making HL one of the most commonly diagnosed cancers in young adults and ranking it third among all cancers in average years of life lost to a malignancy (1). Treatment successes have led to substantial reductions in HL mortality, such that five-year relative survival for US HL patients now exceeds 80% (1) and cure rates exceed 75% (2). Although these statistics place HL among the most favorable of all cancers in terms of survival, long-term HL survivors face substantial ongoing threats to their health and quality of life from both HL recurrence and treatment-related sequelae, including second primary malignancies and cardiovascular disease (2-4).

Some of these risks can be minimized through state-of-the-art initial treatment and close post-treatment medical surveillance. Access to such medical care is known to be influenced by patient social standing, including education, income or other measures of socioeconomic

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status (SES) (5-7), and HL outcomes generally have been reported to be poorer for persons of lower SES (8-10) or non-white race/ethnicity (11,12). However, prior studies to determine how SES impacts survival after HL have been limited by being conducted in clinical series (8,10,13), involving small sample sizes (8,10,13), combining HL with a variety of other cancers (8), or not controlling for particular prognostic factors (9). In addition, although SES and race/ethnicity are strongly correlated in the US (14), no studies to date have examined the joint effects of these factors on survival after HL.

Better understanding of social disparities in HL outcome is important to identifying modifiable barriers leading to the disparities, which in turn should facilitate steps to improve overall outcomes after HL for all patients. Therefore, we assessed the impact of neighborhood SES and race/ethnicity on overall, disease-specific and relative survival after HL in a large population-based case series with a median follow-up of 79 months and substantial heterogeneity in race/ethnicity and SES. Analyses of all-cause death as an endpoint allow us to consider whether the well-documented late complications of HL treatment and disease (2), in addition to the direct health consequences of HL itself, vary by SES and race/ethnicity. Utilizing cancer registry data from patients diagnosed with classical HL from 1988 through 2006 in California, we tested the hypothesis that neighborhood SES and non-Hispanic white race/ethnicity were inversely associated with hazard of death after controlling for other prognostic factors.

MATERIALS AND METHODS

Patients

Cases eligible for the study were all California residents newly diagnosed with classical HL (International Classification of Diseases—Oncology, 3rd edition (15) morphology codes 9650-9667, excluding codes 9659 (nodular lymphocyte predominance), 9661 (Hodgkin granuloma) and 9662 (Hodgkin sarcoma)) during the period January 1, 1988 through December 31, 2006 and reported by state mandate to the California Cancer Registry (CCR). From the CCR, we obtained information routinely recorded at diagnosis for each patient on age, sex, race/ethnicity (non-Hispanic white (hereafter called “white”), Hispanic, black, and Asian/Pacific Islander), summary stage [localized (Ann Arbor stage I), regional (stage II), advanced (stage III/IV)], extent of disease, tumor histologic subtype (nodular sclerosis, mixed cellularity, lymphocyte depletion, lymphocyte rich, or not otherwise specified), and census-block group of residence. With information on extent of disease, we were able to classify patients by the presence of B symptoms (weight loss, night sweats, and fever) and human immunodeficiency virus (HIV) or acquired immunodeficiency syndrome (AIDS). In addition, we obtained registry information on treatment modality (radiation (yes, no), chemotherapy (yes, no/unknown) or combined modality within four months of diagnosis); vital status (routinely determined by the CCR through hospital follow-up and linkages to vital status and other databases) as of December 2007; and, for the deceased, the underlying cause of death as routinely coded by state vital statistics personnel.

As the CCR does not collect individual-level patient SES, we determined neighborhood SES using an index incorporating census block-group averages of education, income, occupation, and cost of living, as described previously (16,17). This SES index was available for the 95% of patients whose residential census block group at diagnosis could be geocoded; patients with a missing block group were randomly assigned to a block group within their county of residence at diagnosis. Each HL patient was assigned an SES quintile based on the distribution in the study population; SES quintiles were then collapsed into two groups (higher- and lower-SES), as described below.

The final study population included 12,492 HL patients ≥ 15 years of age at diagnosis after exclusion, in a hierarchical manner, of those with: 1) unknown race/ethnicity (n=167); 2) registry or death certificate evidence of HIV or AIDS (n=598), because of the substantially poorer outcome of HIV-associated HL during the study period (18,19); 3) HL diagnosis at autopsy, by death certificate only, or with zero/invalid survival time (n=121); and 4) American Indian/Alaskan native race/ethnicity (n=10), as SES-specific life tables were not available for this group. All study protocols were approved by the Institutional Review Board of the Northern California Cancer Center.

Statistical analyses

Outcomes of interest included overall survival, which considers death from all causes, and HL-specific survival, which considers death from HL. For deceased patients, survival time was measured in months from the date of diagnosis to the date of death of any cause for overall survival, and to the date of death from HL for HL-specific survival. Patients who died from other causes were censored at the time of death in analyses of HL-specific survival. Patients alive at the study end date (12/31/2007) were censored at this time or at the date of last known contact. Ninety-four percent of censored patients had a follow-up date within two years of the study end date; neighborhood SES did not differ between patients with and without recent follow-up information. However, the percentage of patients with follow-up within two years was slightly higher for whites (96%), Blacks (96%), and APIs (93%) than for Hispanics (90%).

To evaluate associations with survival controlling for known prognostic factors, we used Cox proportional hazards regression to estimate hazard ratios (HR) and associated 95% confidence intervals (CI). Multivariate regression models included variables significant at $p<0.15$ in univariate models or with *a priori* reasons for inclusion (e.g., age, race/ethnicity, and gender). All variables were included in the multivariate analyses with the exception of initial treatment, which was correlated with stage at diagnosis ($p < 0.01$), the primary factor influencing treatment selection (20). For stratified analyses (Tables 1,4 and 5), neighborhood SES quintiles were collapsed into two groups (quintiles 1, 2, and 3 (lower SES), quintiles 4 and 5 (higher SES)) due to similarities across quintiles in survival patterns. Because of previously established HL survival differences by age (11), we present analyses separately by age group (< 45, ≥45 years). Effect modification was assessed between SES and race/ethnicity, stage at diagnosis, histologic subtype, and gender, and between race/ethnicity and stage at diagnosis, by including interaction terms in the multivariable models. No interaction terms were statistically significant. In all models, the proportional hazards assumption was assessed numerically based on cumulative sums of Martingale residuals (21) and visually based on inspection of the survival curves (log (−log) of the survival distribution function by log (months)). There was evidence of a violation of this assumption with stage; therefore, Cox models were stratified by stage. Regression analyses were conducted using SAS version 9.1 software (SAS institute Inc., Cary, NC, USA).

We calculated relative survival estimates, which adjust for competing causes of death by comparing the observed survival of study patients with their expected survival if they did not have HL, by using NCI's SEER*Stat software version 6.2.4 (http://seer.cancer.gov/seerstat) and proprietary SES-(16), age-, sex-, and race/ethnicity-specific life tables based on the 1990 US census estimates for California.

There was minimal spatial clustering of HL cases in census block groups, as the majority of block groups had only one (55%) or two (28%) cases diagnosed during the 19-year study period. Nevertheless, we performed secondary analyses to adjust for clustering by computing a robust sandwich covariance matrix estimate that accounts for intracluster

dependence (22). Accounting for clustering did not change our findings (data not shown); therefore, we present results unadjusted for spatial clustering.

RESULTS

The 12,492 HL patients were followed for a median of 79.3 months (25.8 months for deceased patients; 104.2 months for living patients), with 14.9% followed for 180 months (15 years) or more. In both age groups, many patient and tumor characteristics varied according to neighborhood SES (Table 1), although most differences were not large. Patient and tumor characteristics also varied by race/ethnicity (Table 2). More than 75% of blacks and Hispanics were in the lower-SES group, compared to fewer than 50% of whites and Asians/Pacific Islanders.

Table 3 shows that, among young adults, worse HL-specific survival was associated with earlier year of diagnosis, older age, male sex, later stage of disease, presence of B symptoms, and lymphocyte depletion histologic subtype. In addition, worse HL-specific survival was associated significantly and independently both with lower neighborhood SES, with a 23% to 64% greater risk of HL-death for the lower SES quintiles (versus the highest SES quintile), and with black or Hispanic race/ethnicity, with the risk of HL-death 74% greater in blacks and 43% greater in Hispanics than in whites. Worse HL-specific survival in older adults was associated with many of the same factors as in young adults. With the exception that the risk of death from all causes was similar for blacks and whites, worse overall survival (Table 3) was associated with many of the same factors as HL-specific survival. Adding neighborhood SES to the multivariate models in Table 3 attenuated the hazard ratios for race/ethnicity but by less than 10%.

Neighborhood SES differences in survival varied by stage at diagnosis, so analyses of SES associations were stratified by stage (Table 4). Although power is limited when stratified by age group and stage, neighborhood SES was associated with overall survival among patients with all stages of disease; in young adults, patients in the lower-SES group had risks of death 103% (stage I), 56% (stage II) and 28% (stages III/IV) greater than patients in the higher-SES group. In older adults, patients in the lower-SES group had risks of death 27% to 35% higher than patients in the higher-SES group. Lower-SES patients also appeared to be at a greater risk of HL-specific death than higher-SES patients. Among young adults, risks of death were 96% (stage II) and 21% (stages III/IV) greater in lower-than higher-SES patients; among older adults, risks were 39% (stage II) and 19% (stages III/IV) greater in lower-than in higher-SES patients. Neighborhood SES was not significantly associated with HL-specific survival in patients with stage I disease, possibly because of the relatively small number of deaths from HL (n=49 for patients 15-44 years; n=101 for patients ≥ 45 years).

When we considered death from cancers other than HL and death from circulatory diseases separately, low-SES was associated with worse survival in young (multivariate adjusted HR for death from other cancers = 1.88, 95% confidence intervals (CI): 1.33-2.67; HR for death from circulatory disease = 1.60, 95% CI: 0.95-2.70) and older (HR for death from other cancers = 1.25, 95% CI: 1.04-1.50; HR for death from circulatory disease = 1.75, 95% CI: 1.37-2.23) adults. Racial/ethnic disparities in survival were apparent only in young adult blacks (HR for death from other cancers = 1.66, 95% CI: 0.99-2.77; HR for death from circulatory disease = 1.73, 95% CI: 0.72-4.13) and Hispanics (HR for death from other cancers = 0.91, 95% CI: 0.58-1.44; HR for death from circulatory disease = 1.58, 95% CI: 0.84-2.97).

Young-adult patients of black race/ethnicity had worse survival in all stages of disease: in this group, risk of death from all causes was 52% to over two-fold greater and risk of death

from HL 65% to over four-fold greater than that in white patients (Table 4). Older-adult black patients had a suggestively higher risk of death from HL, with the risk 46% greater (stages III/IV) than that in white patients. Hispanic patients with later-stage disease similarly had worse survival than white patients. Among Hispanic young adults, the risk of death from all causes was 30% (stage II) to over 140% (unknown stage) greater, and the risk of death from HL was 64% (stage III/IV) to 158% (unknown stage) greater, than in white patients (Table 4). Older-adult Hispanic patients with stage III/IV disease also had a 25% greater risk of death from all causes than whites. Asians/Pacific Islanders had similar survival to white patients.

Relative survival estimates varied by age and SES group. Older adults had worse survival than young adults over the entire study period (Figure 1), and within categories defined by race/ethnicity, gender and stage at diagnosis (Table 5). The higher-SES group had higher relative survival than the lower-SES group for all categories of race/ethnicity, gender and stage at diagnosis (Table 5). Although absolute differences in relative survival by neighborhood SES varied over time within patient subgroups, the disparities between the higher- and lower-SES groups generally persisted for the 15-year study period in both age groups.

DISCUSSION

In this large population-based series of classical HL patients in California, we found that survival was poorer for patients living in lower-SES neighborhoods at diagnosis, and for black or Hispanic patients even after adjustment for neighborhood SES. These findings of social class-associated survival disparities for this highly curable cancer underscore the importance of determining and ameliorating the underlying causes of such disparities so that all patients can benefit from the well-established and successful treatments.

Our findings are supported by previous studies that considered SES and racial/ethnic differences in survival separately (9-12) and by our prior study (based on 922 subjects also included in these analyses) that considered neighborhood SES and race/ethnicity simultaneously (23). HL patients diagnosed in the US Surveillance, Epidemiology and End Results (SEER) regions in 1987-1992 had a 5% increased risk of cancer-specific death with each quintile decrease in area-level median household income (9); in a Brazilian HL clinical series (2001-2005), higher SES was associated with better 2-year overall survival (93% vs. 79%) (10). By contrast, in an Austrian clinical series of HL patients (1969-2002), those of higher SES had worse failure-free survival (13), and in a population-based Danish HL cohort (1994-2003), there was no association between socioeconomic or demographic measures and 5-year relative survival (24). In our prior study, lower neighborhood SES and non-white race/ethnicity were associated with poorer survival in patients 15-44, but not 45-96, years of age (23). Some of these differences in findings may be attributable to different health care systems. For example, Austria and Denmark have well-established universal health insurance systems, whereas the US provides government-supported health insurance only to those aged 65 and over, and Brazil's universal health care system was implemented relatively recently.

At least two studies have considered HL survival in non-white racial/ethnic groups. A US survey of HL patients (diagnosed in 1970-1981), 74% of whom were under 55 years of age at diagnosis, found that blacks had a 44% higher risk of death than whites five to 10 years after diagnosis (12). Our study of SEER data for HL diagnoses in 1983 through 1995 found that non-white young and older adult HL patients had a 40-50% increased risk of HL-specific death, depending on age and symptoms, compared to white patients (11). However,

no previous US studies have considered HL survival in Hispanics, and HL survival studies of APIs have been limited to small series (n < 50) of Taiwanese patients (25,26).

Social disparities in survival may occur because patients with lower-SES or non-white race/ethnicity are diagnosed at a later stage of disease (27), as found in one HL study (28), or receive poorer cancer treatment (27). In our study, the percentages of HL patients with lower neighborhood SES and diagnosed with stage III/IV disease were higher in blacks and Hispanics than in Asians/Pacific Islanders and whites. However, we found neighborhood SES and racial/ethnic differences in survival in patients with all stages of disease, suggesting that factors over and above stage at diagnosis influence the disparities we observed. Improvements in standards for HL treatment likely contributed to the better survival observed in more recent diagnostic years (29). However, we did not have information to evaluate the quality of staging, which largely determines treatment (20), or the completeness of treatment received by study patients. Thus, we could not assess how these factors may have varied by neighborhood SES or race/ethnicity and thereby contributed to our findings. Young-adult black and Hispanic patients with unknown stage of disease had markedly worse survival, suggesting that lower quality of staging in these groups may be related to poorer treatment and, consequently, worse survival. Furthermore, SES is related to having adequate health insurance, a variable not available in this study, and being uninsured or Medicaid-insured has been found to be associated with poorer survival after cancer (30).

Other explanations for our observations of HL outcome disparities by neighborhood SES and race/ethnicity include differences in medical follow-up or integrated care after diagnosis, comorbidities, health behaviors, and other host factors (27). If poor health behaviors and comorbid conditions are more prevalent in lower-SES and/or non-white HL patients, as found for patients with other cancers (27,31-33), then these factors could increase post-treatment complications and reduce survival. Furthermore, inadequate long-term follow-up in patients could result in a delay in diagnosing and treating complications (10). Finally, host genetic factors also may contribute to the observed survival differences by race/ethnicity. For example, racial/ethnic variation in certain immune-function genes may impact survival after HL (34-38).

In our study, relative survival was worse in the lower neighborhood SES group than the higher-SES group in all racial/ethnic categories. With the exception of older cases at 5 and 10 years after diagnosis, we found better relative survival in females than in males, consistent with previously reported five-year relative survival estimates (1). We also noted better overall survival for young-adult females than males, as found previously, including prior to the era of successful HL treatments (11,39). While there was some variation in the magnitude of neighborhood SES disparities in relative survival over the duration of follow-up, we found that the gaps persisted for at least 15 years after diagnosis in groups defined by age, gender, and stage of disease.

Our study had a number of strengths. It used a large, population-based series of patients, including all HL patients diagnosed in California over an 19-year time period; thus, our findings are likely more generalizable than those from some prior studies of disparities in HL, as survival has been shown to be different in patients in population-based cancer registries than in patients in clinical trials (40) or treated in comprehensive cancer centers (41). Another strength is that survival time for our study was uniformly collected, which minimizes bias due to differential follow-up. We also used a measure of neighborhood SES shown to have adequate sensitivity for demonstrating SES gradients in HL incidence (17) and survival (23). Our study has the advantage of using customized SES- and race/ethnicity-specific life tables, which likely estimate the relative survival after HL more accurately than unadjusted/general life tables. Because HL incidence varies by neighborhood SES at

diagnosis (17) and higher-SES populations have longer survival, the use of general population mortality tables to determine the expected mortality for calculations of relative survival would likely overestimate the relative survival rates of these patients.

Our study also was subject to some limitations. We did not have individual-level measures of SES to consider along with our measure of neighborhood SES. While individual and neighborhood SES are associated, neighborhood SES has been shown to underestimate associations observed with individual-level SES (42). Furthermore, area-based SES measures may reveal differences in health outcomes and risk factors not captured by individual-level SES alone, as 23 of 25 studies found a significant association between area SES measures and health outcomes after adjusting for individual-level SES (43). Because cancer registry data lack information on potentially relevant clinical data such as prognostic serum measures (44) or tumor characteristics (e.g., presence of Epstein-Barr virus in tumor cells (23)), our analyses could not examine the impact of these factors on survival. Finally, our study is also subject to the effects of some potential misclassification in cancer registry data, including for race/ethnicity, although we have detected excellent overall agreement with self-reported race/ethnicity for whites and blacks, and intermediate agreement for Hispanics and Asians (45,46); and for the underlying cause of death code, although this previously has been found to be between 84% and 90% accurate (47-49).

While over 75% of all HL patients are now considered cured of their disease (2), our data show that this remarkable clinical accomplishment has not been distributed evenly across socioeconomic and racial/ethnic groups. Rather, lower neighborhood SES and non-white patients are less likely to benefit from optimal treatment and clinical care, even among young adults, an age group for which a cancer diagnosis might be expected to provoke particularly close medical attention and follow-up care. Our findings of similar results for overall and HL-specific survival, as well as the persistence of differences in relative survival by neighborhood SES over time, suggest that neighborhood SES and racial/ethnic disparities in HL survival stem more from differences in the initial treatment and management than in the response to late complications resulting from HL. Therefore, targeted efforts to expand access to high-quality staging and treatment for lower-SES and black and Hispanic HL patients should help to bring survival in these groups up to the standard enjoyed by more privileged patients. In the meantime, efforts are needed to identify additional reasons for these marked survival differences.

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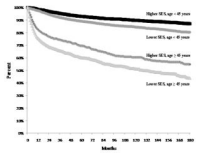

Figure 1.
Relative survival after Hodgkin lymphoma by age (years) and neighborhood socioeconomic status (SES) group (Lower SES = quintiles 1, 2, 3; Higher SES = quintiles 4, 5), California, 1988-2006.

Table 1

Characteristics of Hodgkin lymphoma (HL) patients (N = 12,492) by age at diagnosis and neighborhood socioeconomic status (SES) group, California, 1988-2006.

Characteristic	Age 15 – 44 years n = 8228					Age ≥ 45 years n = 4264				
	Lower-SES (Quintiles 1-3)		Higher-SES (Quintiles 4,5)			Lower-SES (Quintiles 1-3)		Higher-SES (Quintiles 4,5)		
	n=4408	%	n=3820	%	P-value	n=2325	%	n=1939	%	P-value
Sex										
Male	2322	52.7	1961	51.3		1326	57.0	1104	56.9	
Female	2086	47.3	1859	48.7	0.22	999	43.0	835	43.1	0.95
Year of diagnosis										
1988-1992	1190	27.0	1113	29.1		526	22.6	471	24.3	
1993-1997	1131	25.7	969	25.4		581	25.0	476	24.6	
1998-2002	1119	25.4	937	24.5		630	27.1	553	28.5	
2003-2006	968	22.0	801	21.0	0.18	588	25.3	439	22.6	0.16
Race/ethnicity										
Non-Hispanic White	2551	57.9	3033	79.4		1426	61.3	1578	81.4	
Black	407	9.2	128	3.4		172	7.4	53	2.7	
Hispanic	1284	29.1	407	10.7		624	26.8	198	10.2	
Asian/Pacific	166	3.8	252	6.6	<0.01	103	4.4	11	5.7	<0.01
Stage										
I	606	13.8	568	14.9		435	18.7	397	20.5	
II	1982	45.0	1880	49.2		581	30.5	592	30.5	
III/IV	1543	35.0	1155	30.2		1102	47.4	818	42.2	
Missing/unknown	277	6.3	217	5.7	<0.01	207	8.9	132	6.8	<0.01
B Symptoms										
No	1425	32.3	1503	39.4		679	29.2	682	35.2	
Yes	1525	34.6	1222	32.0		817	35.1	654	33.7	
Missing/unknown	1458	33.1	1095	28.7	<0.01	829	35.7	603	31.1	<0.01
Histologic subtype										
Nodular sclerosis	3243	73.6	3027	79.2		990	42.6	939	48.4	

Characteristic	Age 15 – 44 years n = 8228					Age ≥ 45 years n = 4264				
	Lower-SES (Quintiles 1-3)		Higher-SES (Quintiles 4,5)			Lower-SES (Quintiles 1-3)		Higher-SES (Quintiles 4,5)		
	n=4408	%	n=3820	%	P-value	n=2325	%	n=1939	%	P-value
Mixed cellularity	531	12.1	376	9.8		666	28.7	491	25.3	
Lymphocyte depletion	61	1.4	27	0.7		111	4.8	59	3.0	
Lymphocyte rich	123	2.8	81	2.1		113	4.9	84	4.3	
Not otherwise specified	450	10.2	309	8.1	<0.01	445	19.1	366	18.9	<0.01
First course of treatment										
Combined modality	1409	32.0	1535	40.2		299	12.9	399	20.6	
Radiation only	514	11.7	570	14.9		261	11.2	269	13.9	
Chemotherapy only	2010	45.6	1367	35.8		1262	54.3	957	49.4	
None	475	10.8	348	9.1	<0.01	503	21.6	314	16.2	<0.01
Vital status										
Alive	3681	83.5	3398	89.0		958	41.2	958	49.4	
Death from HL	402	9.1	226	5.9		600	25.8	410	21.1	
Death from Non-Hodgkin lymphoma or leukemia	66	1.5	24	0.6		172	7.4	129	6.7	
Death from other cancer	34	0.8	27	0.7		110	4.7	91	4.7	
Death from circulatory disease	42	1.0	24	0.6		186	8.0	107	5.5	
Death from other cause	104	2.4	82	2.2		217	9.3	179	9.2	
Death from unknown cause	79	1.8	39	1.0	<0.01	82	3.5	65	3.4	<0.01

Table 2

Characteristics of Hodgkin lymphoma (HL) patients (N = 12,492) by age at diagnosis and race/ethnicity, California, 1988-2006.

Characteristic	Age 15-44								p-value	Age ≥45								p-value
	Race/ethnicity									Race/ethnicity								
	Non-Hispanic White		Black		Hispanic		Asian/ Pacific Islander			Non-Hispanic White		Black		Hispanic		Asian/ Pacific Islander		
	n=5584	%	n=535	%	n=1691	%	N=418	%		n=3004	%	n=225	%	n=822	%	N=213	%	
Sex																		
Male	2925	52.4	272	50.8	875	51.7	211	50.5		1683	56.0	117	52.0	492	59.9	138	64.8	
Female	2659	47.6	263	49.2	816	48.3	207	49.5	0.79	1321	44.0	108	48.0	330	40.2	75	35.2	0.01
Year of diagnosis																		
1988-1992	1726	30.9	152	28.4	354	20.9	71	17.0		746	24.8	52	23.1	157	19.1	42	19.7	
1993-1997	1467	26.3	146	27.3	405	24.0	82	19.6		757	25.2	60	26.7	188	22.9	52	24.4	
1998-2002	1331	23.8	115	21.5	484	28.6	126	30.1		831	27.7	53	23.6	236	28.7	63	29.6	
2003-2006	1060	19.0	122	22.8	448	26.5	139	33.3	<0.001	670	22.3	60	26.7	241	29.3	56	26.3	<0.001
Stage at diagnosis																		
I	807	14.5	79	14.8	227	13.4	61	14.6		593	19.7	41	18.2	149	18.1	49	23.0	
II	2688	48.1	216	40.4	744	44.0	214	51.2		868	28.9	57	25.3	198	24.1	50	23.5	
III/IV	1753	31.4	206	38.5	611	36.1	128	30.6		1301	43.3	107	47.6	415	50.5	97	45.5	
Missing/unknown	336	6.0	34	6.4	109	6.5	15	3.6	<0.001	242	8.1	20	8.9	60	7.3	17	8.0	0.03
B-Symptoms																		
No	2003	35.9	177	33.1	563	33.3	185	44.3		981	32.7	73	32.4	232	28.2	75	35.2	
Yes	1756	31.5	178	33.3	673	39.8	140	33.5		970	32.3	90	40.0	339	41.2	72	33.8	
Missing/unknown	1825	32.7	180	33.6	455	26.9	93	22.3	<0.001	1053	35.1	62	27.6	251	30.5	66	31.0	<0.001
Histologic subtype																		
Nodular sclerosis	4377	78.4	375	70.1	1197	70.8	321	76.8		1441	48.0	90	40.0	305	37.1	93	43.7	
Mixed cellularity	550	9.9	74	13.8	242	14.3	41	9.8		749	24.9	60	26.7	278	33.8	70	32.9	
Lymphocyte depletion	53	1.0	4	0.8	28	1.7	3	0.7		115	3.8	12	5.3	36	4.4	7	3.3	
Lymphocyte rich	109	2.0	29	5.4	55	3.3	11	2.6		142	4.7	15	6.7	30	3.7	10	4.7	
Not otherwise specified	495	8.9	53	9.9	169	10.0	42	10.1	<0.001	557	18.5	48	21.3	173	21.1	33	15.5	<0.001

Characteristic	Age 15-44								p-value	Age ≥45								p-value
	Race/ethnicity									Race/ethnicity								
	Non-Hispanic White		Black		Hispanic		Asian/ Pacific Islander			Non-Hispanic White		Black		Hispanic		Asian/ Pacific Islander		
	n=5584	%	n=535	%	n=1691	%	N=418	%		n=3004	%	n=225	%	n=822	%	N=213	%	
First course of treatment																		
Combined modality	2081	37.3	132	24.7	551	32.6	180	43.1		528	17.6	28	12.4	106	12.9	36	16.9	
Radiation only	834	14.9	54	10.1	154	9.1	42	10.1		408	13.6	23	10.2	71	8.6	28	13.2	
Chemotherapy only	2128	38.1	279	52.2	802	47.4	168	40.2		1531	51.0	137	60.9	451	54.9	100	47.0	
None/unknown	541	9.7	70	13.1	184	10.9	28	6.7	<0.001	537	17.9	37	16.4	194	23.6	49	23.0	<0.001
Neighborhood socioeconomic status (quintiles)																		
1 (Lowest)	381	6.8	156	29.2	526	31.1	28	6.7		272	9.1	78	34.7	268	32.6	27	12.7	
2	906	16.2	144	26.9	456	27.0	60	14.4		515	17.1	56	24.9	204	24.8	36	16.9	
3	1264	22.6	107	20.0	302	17.9	78	18.7		639	21.3	38	16.9	152	18.5	40	18.8	
4	1510	27.0	86	16.1	253	15.0	119	28.5		738	24.6	27	12.0	110	13.4	47	22.1	
5 (Highest)	1523	27.3	42	7.9	154	9.1	133	31.8		840	28.0	26	11.6	88	10.7	63	29.6	
Vital status																		
Alive	4852	86.9	419	78.3	1431	84.6	377	90.2		1327	44.2	116	51.6	366	44.5	107	50.2	
Death from HL	382	6.8	64	12.0	156	9.2	26	6.2		697	23.2	58	25.8	207	25.2	48	22.5	
Death from Non-Hodgkin lymphoma or Leukemia	56	1.0	14	2.6	18	1.1	2	0.5		214	7.1	7	3.1	66	8.0	14	6.6	
Death from other cancer	50	0.9	4	0.8	6	0.4	1	0.2		152	5.1	11	4.9	26	3.2	12	5.6	
Death from circulatory disease	42	0.8	6	1.1	14	0.8	4	1.0		225	7.5	11	4.9	48	5.8	9	4.2	
Death from other cause	125	2.2	18	3.4	39	2.3	4	1.0		288	9.6	15	6.7	77	9.3	16	7.5	
Death from unknown cause	77	1.4	10	1.9	27	1.6	4	1.0	<0.001	101	3.4	7	3.1	32	3.9	7	3.3	0.07

Table 3

Multivariate adjusted* hazard ratios and 95% confidence interval (95% CI) estimates for death from all causes (overall survival) and death from Hodgkin lymphoma (HL-specific survival) in HL patients diagnosed between 1988 and 2006 in the state of California by age group.

Characteristic	Age 15 - 44 years				Age ≥ 45 years			
	Overall Survival		HL-Specific Survival		Overall Survival		HL-Specific Survival	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Age at diagnosis (per year)	1.03	1.03-1.04	1.02	1.01-1.03	1.07	1.06-1.07	1.07	1.06-1.07
Year of diagnosis								
1988-1992	1.79	1.39-2.31	2.05	1.47-2.87	1.24	1.07-1.44	1.55	1.25-1.92
1993-1997	1.36	1.06-1.75	1.54	1.11-2.15	1.20	1.05-1.38	1.46	1.20-1.78
1998-2002	1.08	0.83-1.41	1.35	0.96-1.89	0.95	0.83-1.09	1.08	0.88-1.32
2003-2006	Reference		Reference		Reference		Reference	
Sex								
Female	Reference		Reference		Reference		Reference	
Male	1.35	1.19-1.53	1.16	0.98-1.36	1.15	1.06-1.25	1.05	0.92-1.19
Race/ethnicity								
Non-Hispanic White	Reference		Reference		Reference		Reference	
Black	1.63	1.33-2.00	1.74	1.32-2.29	1.05	0.86-1.29	1.40	1.06-1.85
Hispanic	1.30	1.11-1.51	1.43	1.17-1.75	1.11	0.99-1.24	1.17	1.00-1.38
Asian/Pacific Islander	1.02	0.74-1.40	1.22	0.82-1.82	1.00	0.82-1.21	1.11	0.83-1.50
Stage at diagnosis								
I	Reference		Reference		Reference		Reference	
II	1.35	1.09-1.67	1.48	1.08-2.02	1.22	1.06-1.39	1.75	1.38-2.23
III/IV	2.15	1.74-2.65	2.59	1.90-3.52	1.92	1.70-2.16	3.31	2.67-4.11
Missing/unknown	1.99	1.49-2.65	1.84	1.20-2.84	1.25	1.05-1.50	1.52	1.10-2.09
B Symptoms								
No	Reference		Reference		Reference		Reference	
Yes	1.72	1.46-2.04	2.15	1.71-2.70	1.31	1.17-1.46	1.77	1.49-2.11
Missing/unknown	1.41	1.18-1.68	1.67	1.31-2.14	1.15	1.02-1.29	1.41	1.16-1.70
Histologic subtype								

Characteristic	Age 15 - 44 years				Age ≥ 45 years			
	Overall Survival		HL-Specific Survival		Overall Survival		HL-Specific Survival	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Nodular sclerosis	Reference		Reference		Reference		Reference	
Mixed cellularity	1.07	0.90-1.27	0.90	0.70-1.15	0.98	0.89-1.08	1.00	0.86-1.16
Lymphocyte depletion	1.69	1.13-2.53	1.78	1.08-2.95	1.59	1.32-1.90	1.68	1.30-2.17
Lymphocyte rich	0.94	0.64-1.40	0.54	0.27-1.10	0.82	0.66-1.02	0.73	0.50-1.07
Not otherwise specified	1.40	1.15-1.69	1.04	0.78-1.38	1.19	1.06-1.33	1.18	1.00-1.40
Neighborhood socioeconomic status (quintiles)								
1 (Lowest)	1.81	1.46-2.24	1.64	1.23-2.20	1.44	1.26-1.66	1.36	1.10-1.68
2	1.57	1.29-1.92	1.48	1.13-1.94	1.26	1.01-1.44	1.27	1.04-1.54
3	1.58	1.30-1.91	1.63	1.26-2.10	1.31	1.15-1.48	1.19	0.98-1.44
4	1.28	1.06-1.56	1.23	0.95-1.61	1.06	0.93-1.20	1.00	0.82-1.21
5 (Highest)	Reference		Reference		Reference		Reference	

*Adjusted for all variables in the table

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Table 4

Multivariate adjusted* hazard ratios and 95% confidence interval (95% CI) estimates for death from all causes (overall survival) and death from Hodgkin lymphoma (HL-specific survival) in HL patients diagnosed between 1988 and 2006 in the state of California by age group, stage of disease at diagnosis, race/ethnicity and neighborhood socioeconomic status (SES).

Stage of disease at diagnosis	Age 15 - 44 years				Age ≥ 45 years			
	Overall Survival		HL-Specific Survival		Overall Survival		HL-Specific Survival	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Stage I								
Race/ethnicity#								
Black	1.52	0.80-2.89	1.96	0.73-5.26	1.23	0.76-2.01	2.02	0.90-4.54
Hispanic	0.82	0.46-1.45	1.70	0.84-3.46	1.08	0.81-1.43	1.44	0.87-2.37
Asian/Pacific Islander	1.21	0.48-3.03	1.15	0.27-4.91	0.83	0.53-1.29	0.69	0.25-1.93
Neighborhood socioeconomic status group**								
Lower SES (Q^+1-3)	2.03	1.36-3.05	1.26	0.69-2.29	1.33	1.08-1.64	1.22	0.81-1.85
Stage II								
Race/ethnicity#								
Black	1.83	1.30-2.59	1.65	1.04-2.63	0.90	0.58-1.39	0.99	0.50-1.96
Hispanic	1.30	1.01-1.67	1.05	0.74-1.49	0.94	0.74-1.20	1.17	0.82-1.68
Asian/Pacific Islander	1.01	0.60-1.70	1.35	0.75-2.44	1.21	0.77-1.91	1.57	0.82-3.01
Neighborhood socioeconomic status group**								
Lower SES (Q^+1-3)	1.56	1.26-1.92	1.96	1.47-2.62	1.35	1.12-1.62	1.39	1.04-1.87
Stage III/IV								
Race/ethnicity#								
Black	1.58	1.18-2.12	1.73	1.19-2.52	1.12	0.85-1.47	1.46	1.03-2.06
Hispanic	1.37	1.11-1.70	1.64	1.26-2.14	1.25	1.09-1.44	1.18	0.96-1.43
Asian/Pacific Islander	1.15	0.73-1.81	1.22	0.68-2.19	1.07	0.81-1.40	1.18	0.82-1.69
Neighborhood socioeconomic status group**								
Lower SES (Q^+1-3)	1.28	1.06-1.54	1.21	0.95-1.54	1.27	1.13-1.43	1.19	1.01-1.40
Unknown stage								

Stage of disease at diagnosis	Age 15 - 44 years				Age ≥ 45 years			
	Overall Survival		HL-Specific Survival		Overall Survival		HL-Specific Survival	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Race/ethnicity[#]								
Black	2.50	1.19-5.26	4.01	1.41-11.38	1.14	0.56-2.31	2.14	0.79-5.81
Hispanic	2.40	1.40-4.14	2.58	1.09-6.11	0.83	0.53-1.29	0.82	0.37-1.82
Asian/Pacific Islander	-	-	-	-	0.57	0.26-1.24	0.41	0.09-1.77
Neighborhood socioeconomic status group[**]								
Lower SES (Q[+]1-3)	1.25	0.79-1.99	0.92	0.46-1.83	1.17	0.86-1.61	1.43	0.82-2.47

[*] Adjusted for age at diagnosis (continuous), sex, year of diagnosis (1988-92, 1993-1997, 1998-2002, 2003-6) presence of B-symptoms (yes, no, unknown), histologic subtype (nodular sclerosis, mixed cellularity, lymphocyte depletion, lymphocyte rich, not otherwise specified).

[+] Quintile

[**] Reference group = Higher SES (Q 4,5).

[#] Reference group = non-Hispanic white race/ethnicity.

Table 5

5-, 10-, and 15-year relative survival (standard error (SE)) by patient characteristics, age group, and neighborhood socioeconomic status (SES) group for Hodgkin lymphoma patients (n = 12,492) diagnosed between 1988 and 2006 in the state of California.

	5-Year Relative Survival (SE)		10-Year Relative Survival (SE)		15-Year Relative Survival (SE)	
Patient Characteristic	**Age 15-44 years**	**Age ≥ 45 years**	**Age 15-44 years**	**Age ≥ 45 years**	**Age 15-44 years**	**Age ≥ 45 years**
White						
Lower SES (Q^+ 1-3)	90.0 (0.6)	61.6 (1.6)	86.1 (0.8)	53.2 (2.1)	82.1 (1.1)	44.8 (3.1)
Higher SES (Q^+ 4,5)	93.5 (0.5)	69.8 (1.4)	90.7 (0.6)	59.8 (1.9)	88.1 (0.8)	53.5 (2.7)
Black						
Lower SES (Q^+ 1-3)	84.1 (2.0)	68.7 (4.5)	78.8 (2.5)	56.1 (6.0)	74.6 (3.1)	50.8 (8.5)
Higher SES (Q^+ 4,5)	85.4 (3.3)	78.5 (7.0)	80.4 (4.0)	75.2 (8.8)	80.4 (4.0)	72.0 (12.1)
Hispanic						
Lower SES (Q^+ 1-3)	88.9 (1.0)	56.0 (2.4)	82.2 (1.3)	48.5 (3.2)	78.1 (1.8)	41.9 (4.8)
Higher SES (Q^+ 4,5)	91.9 (1.5)	64.4 (4.1)	84.7 (2.3)	58.1 (5.3)	79.7 (3.0)	53.9 (7.3)
Asian/ Pacific Islander						
Lower SES (Q^+ 1-3)	90.6 (2.5)	50.4 (6.0)	87.5 (3.1)	35.6 (7.8)	81.4 (4.6)	27.8 (13.6)
Higher SES (Q^+ 4,5)	92.6 (1.9)	71.9 (5.3)	91.0 (2.3)	62.1 (6.8)	89.0 (3.2)	56.0 (9.5)
Male						
Lower SES (Q^+ 1-3)	86.9 (0.8)	60.1 (1.7)	82.1 (1.0)	51.6 (2.2)	77.6 (1.2)	43.7 (3.2)
Higher SES (Q^+ 4,5)	91.8 (0.7)	70.9 (1.7)	88.3 (0.9)	60.5 (2.2)	84.7 (1.1)	52.0 (3.1)
Female						
Lower SES (Q^+ 1-3)	91.7 (0.7)	60.0 (1.9)	87.1 (0.9)	50.5 (2.5)	83.3 (1.2)	43.8 (3.7)
Higher SES (Q^+ 4,5)	94.3 (0.6)	67.8 (2.0)	91.4 (0.8)	60.2 (2.6)	89.6 (0.9)	57.7 (3.8)
Stages I						
Lower SES (Q^+ 1-3)	93.7 (1.1)	78.1 (2.8)	91.5 (1.4)	65.5 (4.0)	86.4 (2.1)	54.1 (6.1)
Higher SES (Q^+ 4,5)	96.5 (0.9)	80.1 (2.6)	95.4 (1.1)	73.0 (3.5)	93.3 (1.4)	65.7 (5.4)
Stage II						

	5-Year Relative Survival (SE)		10-Year Relative Survival (SE)		15-Year Relative Survival (SE)	
Patient Characteristic	**Age 15-44 years**	**Age ≥ 45 years**	**Age 15-44 years**	**Age ≥ 45 years**	**Age 15-44 years**	**Age ≥ 45 years**
Lower SES (Q^+ 1-3)	91.8 (0.7)	70.2 (2.4)	87.3 (0.9)	59.3 (3.4)	84.1 (1.2)	51.8 (5.4)
Higher SES (Q^+ 4,5)	95.2 (0.5)	79.6 (2.1)	93.1 (0.7)	68.6 (3.0)	90.3 (1.0)	64.1 (4.3)
Stage III/IV						
Lower SES (Q^+ 1-3)	83.9 (1.0)	46.7 (1.8)	78.6 (1.2)	39.3 (2.3)	73.9 (1.6)	33.3 (3.1)
Higher SES (Q^+ 4,5)	87.7 (1.0)	56.6 (2.1)	83.0 (1.3)	47.3 (2.6)	79.9 (1.5)	42.2 (3.6)

$^+$Quintile