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Excess Incidence of Squamous Cell Esophageal Cancer among US Black Men: Role of Social Class and Other Risk Factors

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Data from a population-based case-control study were used to evaluate the relation between social class factors and squamous cell esophageal cancer and the extent to which alcohol, tobacco, diet, and low income contribute to the higher incidence among Black men than among White men in the United States. A total of 347 male cases (119 White, 228 Black) and 1,354 male controls (743 White, 611 Black) were selected from three US geographic areas (Atlanta, Georgia, Detroit, Michigan, and New Jersey). Cases were residents of the study areas aged 30–79 years who had been diagnosed with histologically confirmed esophageal cancer between 1986 and 1989. The adjusted odds ratios for subjects with annual incomes less than $10,000 versus incomes of $25,000 or more were 4.3 (95% confidence interval: 2.1, 8.7) for Whites and 8.0 (95% confidence interval: 4.3, 15.0) for Blacks. The combination of all four major risk factors—low income, moderate/heavy alcohol intake, tobacco use, and infrequent consumption of raw fruits and vegetables—accounted for almost all of the squamous cell esophageal cancers in Whites (98%) and Blacks (99%) and for 99% of the excess incidence among Black men. Thus, lifestyle modifications, especially a lowered intake of alcoholic beverages, would markedly decrease the incidence of squamous cell esophageal cancer in both racial groups and would narrow the racial disparity in risk. Further studies on the determinants of social class may help to identify a new set of exposures for this tumor that are amenable to intervention. *Am J Epidemiol* 2001;153:114–22.

alcohol drinking; case-control studies; diet; esophageal neoplasms; racial stocks; risk factors; social class; tobacco

The incidence of squamous cell esophageal cancer is more than five times higher among US Black men (16.8 per 100,000) than among US White men (3.0 per 100,000) (1). To evaluate reasons for this striking racial disparity in risk, we conducted a population-based case-control study of squamous cell esophageal cancer among White and Black men in three areas of the United States. Previous analyses found that heavy drinking and smoking were the major risk factors for this tumor in both Blacks and Whites (2) and that frequent consumption of raw fruits and vegetables reduced risk (3). In this paper, we evaluate the relation between social class factors and squamous cell esophageal cancer and the extent to which alcohol, tobacco, diet, and low income contribute to the higher incidence among Black men than among White men in the United States.

MATERIALS AND METHODS

Methods for selection of cases and controls have been published in detail elsewhere (2). In brief, concurrent case-control studies of four cancers (multiple myeloma and cancers of the esophagus, prostate, and pancreas) were conducted in three geographic areas of the United States during 1986–1989. For efficiency, one large control group was chosen for all four types of cancer. For the esophageal cancer component, all Black and White male residents of Atlanta, Georgia, Detroit, Michigan, and the state of New Jersey aged 30–79 years who had been diagnosed with histologically confirmed esophageal cancer between August 1, 1986 and April 30, 1989 were eligible for study. Controls were selected for similarity with the expected age, race, gender, and area distribution of the four types of cancer combined. Controls aged 30–64 years were selected using a random digit dialing technique (4), whereas controls aged 65–79 years were randomly chosen from computerized listings of Medicare registrants provided by the Health Care Financing Administration.

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Abbreviations: CI, confidence interval; OR, odds ratio; PAR, population attributable risk; SOC, Standard Occupational Classification.

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In-person interviews lasting approximately 60 minutes were conducted directly with the subjects, usually in their homes, by trained interviewers. Informed consent for participation in the study was obtained from each subject prior to interview. Detailed information was obtained on sociodemographic factors, use of alcohol and tobacco, usual adult diet, usual occupation, medical and dental history, and family history of cancer. Interviews were completed for 68 percent of both White cases and Black cases. The response rates were 72 percent and 76 percent, respectively, for the White and Black Health Care Financing Administration controls. For the random digit dialing controls, the response rates were 76 percent and 79 percent, respectively, for Whites and Blacks in the interview phase and 86 percent in the household screening phase. The main reasons for nonresponse were death (19 percent of cases, 1 percent of controls), illness (8 percent of cases, 4 percent of controls), and refusal (4 percent of cases, 16 percent of controls).

Analyses were based on 347 cases (119 White, 228 Black) and 1,354 controls (743 White, 611 Black). Twenty-six cases (5 White, 21 Black) under 65 years of age were not included in the analysis because they reported not having a telephone, a criterion for control selection.

Subjects were asked to report their marital status and place of birth (data suggest that Blacks born in the South are more economically disadvantaged than those born elsewhere (5)), total income (including money received by a spouse) before taxes during the year prior to interview and the number of persons supported by this income, the highest grade or level of schooling completed, how often they usually visited a dentist (an indicator of access to or propensity for seeking medical care), and usual occupation. Occupation was coded using the *Standard Occupational Classification* [SOC] *Manual* (6). Occupations were grouped into the following six categories suggested by the SOC manual for presentation of cross-tabulated data: administrative/technical (SOC codes 11–39), clerical/sales (SOC codes 40–47), service occupations (SOC codes 13 and 28), farming (SOC codes 55–58), production/transportation (SOC codes 60–83), and laborers/helpers (SOC codes 85–87) (6). To characterize each SOC code as representing high, medium, or low socioeconomic status, one of us (M. D.) created an occupation-based socioeconomic status indicator using information (average earnings and number of years of training required for each job) presented in the 1987 version of *CFKR Career Materials* (CFKR Career Materials, P.O. Box 437, Meadow Vista, CA 95722). Questionnaire data on income during the year prior to interview and the number of people supported by that income were compared with poverty thresholds by size of family using data supplied by the Bureau of the Census for the years covering the study period, 1985–1989. We created a binary poverty index variable using census data from the year prior to interview to determine whether each study subject was above or below the poverty threshold.

Data were analyzed using unconditional logistic regression (7). Odds ratios and 95 percent confidence intervals were obtained using the EPICURE program for personal computers (8). Models included one social class indicator and the following variables: age at diagnosis/interview (<50, 50–59, 60–69, and ≥70 years), geographic area, years of cigarette smoking (0, 1–29, 30–39, and ≥40 years), number of alcoholic drinks consumed per week (0–7, 8–14, 15–35, 36–84, and ≥85), and number of servings of raw fruits and vegetables consumed per week (<7.1, 7.1–11.6, 11.7–18.3, and >18.3). Additional models included adjustment for annual income (≥$25,000, $10,000–$24,999, and <$10,000). The combined effects of income with diet and income with alcohol drinking and cigarette smoking were examined by fitting multiplicative and additive risk models (8, 9). Details concerning the dietary assessment instrument and categorization of the smoking, drinking, and raw fruit and vegetable variables have been published previously (2, 3, 10).

The population attributable risk (PAR) and summary PAR were used to estimate the amount of esophageal cancer in the population that might be due to a specific risk factor or combination of risk factors, respectively. The method of Bruzzi et al. (11), based on unconditional logistic regression, was used to compute race-specific PARs and summary PARs adjusted for the same confounding variables as those used in calculation of the odds ratios. The summary PARs were calculated by fitting logit models that were additive in the main exposures. Two-sided confidence intervals were calculated using the method of Benichou and Gail (12). The sum of individual PARs may exceed 100 percent, because subjects are often exposed to more than one risk factor; the summary PAR takes into account multiple exposures. The PARs and summary PARs were also used to estimate the proportion of the Black excess that might be attributable to a risk factor or a combination of risk factors. They were based only on subjects with complete data for the income, alcohol, tobacco, and dietary variables (107 White and 190 Black cases; 631 White and 520 Black controls).

RESULTS

Social class factors

Table 1 presents numbers of cases and controls and odds ratios by race for sociodemographic indicators potentially related to risk. Compared with Whites, Blacks had a lower annual income, were more often widowed or divorced, had less formal education, visited the dentist less often, were less likely to hold an administrative or technical job and more likely to be employed as a laborer or helper, had a lower occupation-based socioeconomic status, were more likely to have been born in the South, and were more likely to be at or below the poverty threshold.

Adjusted risks were strongly associated with low income, reaching 4.3 (Whites) and 8.0 (Blacks) for subjects with annual incomes less than $10,000 compared with $25,000 or more. Additional adjustment for alcohol use (in 10 categories, the highest being ≥120 drinks per week) had little impact on the risk estimates for income.

To evaluate income on a relative scale, we recalculated odds ratios for Blacks and Whites separately using approximate race-specific quartiles as cutpoints. The odds ratios for Whites associated with incomes of $25,000–49,999,

TABLE 1. Risk of squamous cell esophageal cancer according to sociodemographic factors in White men and Black men, 1986–1989

Factor	White men						Black men					
	No. of cases (n = 119)	No. of controls (n = 743)	Adjusted odds ratio*	95% confidence interval	Adjusted odds ratio†	95% confidence interval	No. of cases (n = 228)	No. of controls (n = 611)	Adjusted odds ratio*	95% confidence interval	Adjusted odds ratio†	95% conidence interval
Annual income												
≥$25,000	33	390	1.0				20	171	1.0			
$10,000–$24,999	52	240	2.0	1.1, 3.6			63	238	2.3	1.3, 4.3		
<$10,000	28	53	4.3	2.1, 8.7			127	161	8.0	4.3, 15.0		
Marital status												
Married	80	594	1.0		1.0		104	399	1.0		1.0	
Widowed	15	49	1.1	0.5, 2.3	0.9	0.4, 1.9	41	77	2.5	1.5, 4.4	1.7	0.9, 3.1
Divorced	15	61	1.0	0.5, 2.1	0.6	0.3, 1.4	59	112	1.6	1.0, 2.4	1.1	0.6, 1.7
Never married	9	39	1.5	0.6, 3.8	1.1	0.4, 2.7	24	23	3.9	1.8, 8.2	2.0	0.9, 4.5
Educational level												
>High school	36	343	1.0		1.0		13	122	1.0		1.0	
High school	34	206	1.1	0.9, 2.6	0.9	0.5, 1.6	49	136	2.8	1.4, 5.9	2.1	0.9, 4.7
<High school	49	188	1.5	0.9, 2.6	1.0	0.5, 1.8	165	353	3.1	1.6, 6.1	1.8	0.9, 3.9
Frequency of dental visits												
At least once per year	44	395	1.0		1.0		35	175	1.0		1.0	
Every 2–4 years	14	129	0.9	0.4, 1.8	0.8	0.4, 1.6	29	95	1.2	0.6, 2.2	1.0	0.5, 1.9
Rarely	56	151	1.8	1.1, 3.0	1.4	0.8, 2.5	143	288	1.7	1.1, 2.8	1.4	0.8, 2.2
Usual occupational group												
Administrative/technical	26	255	1.0		1.0		7	72	1.0		1.0	
Clerical/sales	15	142	0.7	0.4, 1.4	0.6	0.3, 1.2	12	59	1.3	0.4, 4.1	0.8	0.3, 2.7
Service	10	39	1.8	0.7, 4.8	1.3	0.5, 3.4	33	72	2.5	0.9, 6.8	1.1	0.4, 3.1
Farming	1	8	1.0	0.0, 10.3	0.6	0.0, 7.0	6	11	4.3	1.0, 18.0	1.3	0.3, 6.5
Production/transportation	64	282	1.3	0.7, 2.2	0.9	0.5, 1.7	129	345	2.4	1.0, 5.7	1.2	0.5, 3.0
Laborers/helpers	3	14	1.7	0.4, 7.6	1.2	0.3, 5.1	39	49	4.2	1.6, 11.3	1.5	0.5, 4.4
Socioeconomic status (based on usual occupation)												
High	16	163	1.0		1.0		5	35	1.0		1.0	
Medium	45	361	1.3	0.6, 2.5	1.1	0.5, 2.2	48	190	1.4	0.5, 4.3	0.8	0.2, 2.5
Low	58	216	1.8	0.9, 3.5	1.3	0.6, 2.6	173	383	1.8	0.6, 5.3	0.7	0.2, 2.3
Place of birth												
Non-Southern United States	85	495	1.0		1.0		38	115	1.0		1.0	
Southern United States	14	154	1.4	0.6, 3.4	1.3	0.5, 3.1	179	451	1.4	0.8, 2.3	1.2	0.7, 2.0
Foreign country	17	67	2.4	1.2, 4.8	2.1	1.0, 4.4	1	22	0.2	0.0, 2.1	0.2	0.0, 2.3
Poverty index												
Above poverty level	95	636	1.0		1.0		95	450	1.0		1.0	
At or below poverty level	18	40	2.6	1.3, 5.4	1.1	0.4, 3.4	114	118	4.2	2.8, 6.4	1.8	0.9, 3.6

* Adjusted for age, study area, alcohol use, years of cigarette smoking, and raw fruit and vegetable consumption.
† Adjusted for age, study area, alcohol use, years of cigarette smoking, raw fruit and vegetable consumption, and annual income.

TABLE 2. Joint odds ratios for annual income and categories of cigarette smoking and alcoholic beverage use among Black men and White men with squamous cell esophageal cancer, 1986–1989

Smoking status* and no. of drinks per week	Annual income					
	≥$25,000		$10,000–$24,999		<$10,000	
	Odds ratio†	95% confidence interval	Odds ratio†	95% confidence interval	Odds ratio†	95% confidence interval
Light smoker						
Drinks/week						
0–14	1.0		7.8	1.7, 35.7	14.1	2.9, 67.6
15–35	2.0	0.2, 23.1	14.6	2.9, 73.8	71.8	15.0, 343.9
>35	38.7	7.1, 210.4	98.8	20.9, 467.3	231.6	48.2, 1,114
Heavy smoker						
Drinks/week						
0–14	4.1	0.8, 20.9	12.0	2.6, 55.0	49.2	10.9, 221.7
15–35	28.4	6.5, 124.7	46.2	10.4, 204.4	80.4	17.6, 367.9
>35	34.4	7.7, 154.7	94.5	21.9, 408.7	420.6	92.4, 1,914

* Light smoker: nonsmoker or smoker of <1 pack per day. Heavy smoker: smoker of ≥1 pack per day.
† Adjusted for age, study area, raw fruit and vegetable consumption, and race.

$15,000–24,999, and <$15,000 were 1.3, 2.1, and 3.9, respectively, compared with an income of $50,000 or more. For Blacks, the odds ratios associated with incomes of $15,000–24,999, $8,000–14,999, and <$8,000 were 2.3, 3.0, and 8.7, respectively, compared with an income of $25,000 or more.

Significant associations were also seen for Blacks whose marital status was widowed (odds ratio (OR) = 2.5) or never married (OR = 3.9) versus married, whose educational level was high school graduation (OR = 2.8) or less (OR = 3.1) versus more than a high school education, and whose usual employment was as a laborer or helper (OR = 4.2) versus an administrative/technical job. Odds ratios were significantly elevated in both races for men who rarely visited a dentist (ORs were 1.8 for Whites and 1.7 for Blacks) and for those with incomes at or below the poverty level (ORs were 2.6 for Whites and 4.2 for Blacks). Nonsignificant excess risks were seen for low occupation-based socioeconomic status (ORs were 1.8 for both races) and for place of birth in the South (ORs were 1.4 for both races). When adjusted for annual income, all risks associated with other social class variables were reduced and not significantly elevated. Risks for annual income, however, remained significantly elevated when adjusted for the other social class variables.

Combined exposures

As table 2 shows, the overall risks associated with income category in combination with smoking and drinking were consistent with independent effects on a multiplicative scale ($p = 0.116$) but not on an additive scale ($p < 0.001$). Gradients of increasing risk with decreasing income were seen for each drinking/smoking category. While increasing risks for drinking/smoking were seen for each income category, the risks were highest among heavy drinkers (>35 drinks per week) with annual incomes of <$10,000. As table 3 shows, the overall risks associated with income category combined with frequency of raw fruit and vegetable consumption were not statistically different from either a multiplicative model ($p = 0.600$) or an additive model ($p = 0.473$). Large differences in risk were seen for income level within each fruit/vegetable consumption category, but there were only small differences in risk for fruit/vegetable con-

TABLE 3. Joint odds ratios for annual income and frequency of raw fruit and vegetable consumption among White men and Black men with squamous cell esophageal cancer, 1986–1989

Consumption of raw fruits and vegetables (no. of servings per week)	Annual income					
	≥$25,000		$10,000–$24,999		<$10,000	
	Odds ratio*	95% confidence interval	Odds ratio*	95% confidence interval	Odds ratio*	95% confidence interval
>18.3	1.0		3.9	1.4, 11.0	7.8	2.6, 23.4
11.7–18.3	3.4	1.3, 9.2	4.5	1.6, 12.2	14.9	5.1, 43.2
7.1–11.6	1.8	0.6, 5.3	5.0	1.8, 13.5	15.9	5.7, 44.1
<7.1	2.5	0.9, 7.1	7.2	2.7, 19.2	17.0	6.3, 46.3

* Adjusted for age, study area, years of cigarette smoking, number of alcoholic drinks per week, and race.

TABLE 4. Odds ratios and population attributable risks for established risk factors* among White men and Black men with squamous cell esophageal cancer, 1986–1989

Risk factor	Odds ratio†	95% confidence interval	% of controls exposed	PAR†,‡ (%)	95% confidence interval	Incidence in the nonexposed (per 100,000)§	% of Black excess explained
Alcohol							
White men	6.8	3.5, 13.4	50.1	76.6	63.0, 90.1	0.84	
Black men	8.3	4.3, 15.8	56.7	82.3	72.0, 92.7	3.43	83.5
Tobacco							
White men	3.1	1.2, 8.5	78.1	65.0	35.9, 94.0	1.26	
Black men	2.5	1.1, 5.6	77.6	57.3	28.6, 86.0	8.28	55.6
Diet							
White men	2.0	1.1, 3.9	73.7	43.9	14.1, 73.6	2.02	
Black men	1.7	1.0, 3.1	76.9	37.1	7.1, 67.0	12.20	35.6
Income							
White men	2.3	1.3, 4.0	41.7	38.5	18.2, 58.7	2.21	
Black men	4.3	2.4, 7.9	70.4	69.3	53.9, 84.8	5.96	76.3

* Established risk factors: ≥8 alcoholic drinks per week, tobacco smoking (cigarettes, pipes, or cigars) for 6 months or more, <18 servings of raw fruits and vegetables per week, and an income of <$25,000 per year.
† Odds ratios and population attributable risks were adjusted for age, study area, and the other established risk factors.
‡ PAR, population attributable risk.
§ The total incidence rate was 3.6/100,000 for Whites and 19.4/100,000 for Blacks.

sumption within income categories. We used income as the measure of social class in the PAR and summary PAR estimates because its dominant effect subsumed the other social class variables and it appeared to have effects independent of alcohol, smoking, and diet in our analysis.

PARs

Table 4 presents odds ratios and PARs for the four major risk factors: alcohol (≥8 drinks per week), tobacco (smoking of cigarettes, pipes, or cigars for 6 months or longer), diet (<18 servings of raw fruits or vegetables per week), and income (<$25,000 per year). Odds ratios for both races were associated with moderate/heavy use of alcohol (ORs were 6.8 for Whites and 8.3 for Blacks) and any use of tobacco (ORs were 3.1 for Whites and 2.5 for Blacks). The highest PARs were seen for moderate/heavy alcohol consumption (76.6 percent in Whites and 82.3 percent in Blacks). These risks increased further when alcohol use was redefined as consuming at least one drink per month for 6 months or longer (Whites: OR = 11.7, PAR = 89.8 percent; Blacks: OR = 10.9, PAR = 89.4 percent). We also calculated partial PARs for level of alcohol consumption in Blacks and Whites combined (table 5). Compared with subjects who consumed fewer than eight alcoholic drinks per week, the partial PARs were 7.6 percent, 24.2 percent, and 49.1 percent for subjects who consumed 8–14, 15–35, and ≥36 drinks per week, respectively.

The PARs for tobacco use in Whites and Blacks were 65.0 percent and 57.3 percent, respectively (table 4). Use of

TABLE 5. Odds ratios and population attributable risks for squamous cell esophageal cancer by level of alcoholic beverage use among White men and Black men combined, 1986–1989

Level of alcohol use (no. of drinks per week)	Odds ratio*,†	95% confidence interval	% of controls exposed	PAR†,‡ (%)	95% confidence interval
≥8	7.9	4.9, 12.5	53.1	81.0	73.2, 88.8
8–14	3.2	1.8, 5.8	17.6	7.6	3.6, 11.7
15–35	6.2	3.7, 10.3	22.7	24.2	18.4, 30.1
≥36	16.9	10.1, 28.1	12.9	49.1	42.8, 55.4

* Compared with a risk of 1.0 for drinkers of fewer than eight alcoholic drinks per week.
† Adjusted for age, study area, raw fruit and vegetable consumption, years of cigarette smoking, race, and income.
‡ PAR, population attributable risk.

tobacco and moderate/heavy use of alcohol were not markedly different for Whites and Blacks when the exposures were characterized as dichotomous variables. An earlier analysis examined the joint effects of cigarette smoking (in two levels) and alcohol drinking (in five levels) and found that odds ratios were higher among Blacks than among Whites for every level of drinking/smoking (2). For example, in comparison with light smokers (nonsmokers, ex-smokers, and current smokers of <1 pack/day) who had fewer than eight alcoholic drinks per week, the odds ratios for light smokers who had 15–35 drinks per week were 4.6 (95 percent CI: 1.7, 12.8) among Whites and 10.6 (95 percent CI: 4.1, 27.2) among Blacks. Among heavy smokers (current smokers of ≥1 pack/day) who had 15–35 drinks per week, the odds ratios were 22.1 (95 percent CI: 7.8, 62.3) for Whites and 36.8 (95 percent CI: 13.9, 97.2) for Blacks.

Elevated risks were associated with low (versus high) consumption of raw fruits and vegetables (ORs were 2.0 for Whites and 1.7 for Blacks) (table 4). The PARs for low intake were 43.9 percent in Whites and 37.1 percent in Blacks.

An ethnic difference was evident for subjects with annual incomes less than $25,000 versus $25,000 or more (ORs were 2.3 for Whites and 4.3 for Blacks). The percentage of controls with low income was also higher among Blacks (70.4 percent) than among Whites (41.7 percent), yielding a PAR for low income of 38.5 percent in White men and 69.3 percent in Black men. Because the four risk factors are associated individually with odds ratios greater than 2.0 and with exposure rates that exceed 40 percent, each factor separately explains a substantial portion of the disease.

The annual age-adjusted incidence rates for squamous cell esophageal cancer for the three geographic areas combined were 19.4 per 100,000 for Black men and 3.6 per 100,000 for White men—an excess of more than 400 percent among Blacks, or 15.8 cases per 100,000 per year. To estimate what the race-specific annual incidence rates of this tumor would be if men consumed fewer than eight alcoholic drinks per week, we applied the complement of the race-specific PAR (the proportion of the disease not explained by this risk factor) to the annual age-adjusted incidence rates for the three areas combined. If all of the men consumed fewer than eight drinks per week, annual incidence rates would be 0.8 per 100,000 person-years for Whites ($3.6 \times (1 - 0.766)$) and 3.4 per 100,000 person-years for Blacks ($19.4 \times (1 - 0.823)$). Conversely, the annual incidence rates due to this factor would be 16.0 per 100,000 per year for Blacks and 2.8 per 100,000 per year for Whites, an excess among Blacks of 13.2 cases per 100,000 per year. On the basis of these calculations, we estimated that high levels of drinking would account for 83.5 percent of the excess in incidence rates among Black men (13.2 cases per 100,000 per year of the 15.8 cases per 100,000 per year difference between the Black and White incidence rates). For the other three factors, the corresponding annual incidence rates for White and Black men would be 1.3 and 8.3, respectively, if all men never smoked tobacco; 2.0 and 12.2, respectively, if all men consumed 18 or more servings of raw fruits and vegetables per week; and 2.2 and 6.0 if all men had annual incomes of $25,000 or greater. Unlike the situation with alcohol, tobacco, and diet, the proportions of the disease accounted for by low income (69 percent for Blacks vs. 38 percent for Whites) differ notably by race, because of the substantially higher odds ratio and exposure rate in Blacks than in Whites. Thus, a considerable amount of the excess incidence rate among Black men is explained by low income.

Summary PARs

Table 6 presents summary PARs for various combinations of the four major risk factors. Because alcohol drinking and tobacco use are recognized as the dominant causes of squamous cell esophageal cancer in Western populations, only PARs for combinations including alcohol and tobacco use are presented. The summary PARs for tobacco and moderate/heavy alcohol use were similar for Whites (92.4 percent) and Blacks (91.9 percent). On the basis of these PAR estimates, we calculated that high levels of alcohol drinking or tobacco use would account for 91.8 percent of the excess

TABLE 6. Summary population attributable risks for selected combinations of established risk factors* among White men and Black men with squamous cell esophageal cancer, 1986–1989

Risk factors	White men			Black men			% of Black excess explained
	PAR†,‡ (%)	95% confidence interval	Incidence rate in the nonexposed (per 100,000)§	PAR‡ (%)	95% confidence interval	Incidence rate in the nonexposed (per 100,000)¶	
Alcohol and tobacco	92.4	84.5, 100	0.27	91.9	85.2, 98.6	1.57	91.8
Alcohol, tobacco, and diet	96.2	92.0, 100	0.14	95.3	87.1, 98.3	0.91	95.1
Alcohol, tobacco, and income	96.5	92.7, 100	0.13	98.0	96.0, 100	0.39	98.4
Alcohol, tobacco, diet, and income	98.2	96.2, 100	0.06	98.8	97.6, 100	0.23	98.9

* Established risk factors: ≥8 alcoholic drinks per week, tobacco smoking for 6 months or longer, <18 servings of raw fruits and vegetables per week, and an income of <$25,000 per year.

† PAR, population attributable risk.

‡ Adjusted for age, study area, and the other established risk factors.

§ Total incidence rate was 3.6/100,000 for Whites.

¶ Total incidence rate was 19.4/100,000 for Blacks.

incidence rate among Black men. Since these exposures tend to overlap in the same individuals, once the effects of one variable are considered, the addition of each other factor accounts for proportionately less of the total disease. Thus, the addition of low intake of raw fruits and vegetables or low income to the PARs for tobacco smoking and moderate/heavy alcohol use raised the PARs only slightly. In combination, however, they explained virtually all of the disease (98.2 percent in Whites, 98.8 percent in Blacks) and accounted for virtually all of the excess incidence (98.9 percent) among Black men.

DISCUSSION

In previous reports from our population-based case-control study of squamous cell esophageal cancer (2, 3), we noted that moderate/heavy use of alcohol, tobacco smoking, and infrequent consumption of raw fruits and vegetables were major risk factors in both Black men and White men in the United States. In this analysis, we found elevated risks of esophageal cancer in both Blacks and Whites in relation to various indicators of low social class, especially low annual income; the social class associations contributed to the higher incidence among Blacks than among Whites and appeared to be independent of other risk factors.

In computing PARs, we found that alcoholic beverage consumption of eight or more drinks per week accounted for 77 percent of the disease in White men and 82 percent in Black men, and for 84 percent of the excess incidence among Black men. In both races combined, heavy consumption of alcoholic beverages (>35 drinks per week) accounted for 49 percent of the tumors. The combination of tobacco and moderate/heavy alcohol use was responsible for 92 percent of the tumors in both White men and Black men, and for 92 percent of the excess incidence among Blacks. Consideration of all four risk factors, including diet and social class, accounted for virtually all of the disease, including the Black/White differential in incidence. However, it is not clear why these four risk factors are responsible for 15.8 more cases of squamous cell esophageal cancer per 100,000 per year among Black men than among White men. In an earlier analysis of alcohol-related cancer risk in our study population, we suggested that ethnic variations in susceptibility to lifestyle and other environmental exposures might be involved (13).

Since it was not known which sociodemographic measures were most strongly related to risk of esophageal cancer, we examined a large number of variables, including education, income (annual income and poverty index), occupation (usual occupational group and occupation-based socioeconomic status), marital status, place of birth, and frequency of dental visits. Income was the social class variable most strongly associated with risk. In agreement with previous studies (14–16), we found significantly elevated risks for the lowest level of annual income versus the highest (4.3 for Whites and 8.0 for Blacks, after adjustment for the potentially confounding factors alcohol use, cigarette smoking, and diet). In addition to their higher risks, Black men had a greater prevalence of controls with incomes less than $25,000, resulting in a PAR for low income that was 80 percent higher among Black men. A comparison of the distribution of annual family income reported by our population controls with that from 1990 US Census data for the relevant race groups, age groups, and geographic areas revealed that the percentages of low income (i.e., <$10,000) subjects from each source were similar (Blacks: census = 9 percent, study = 8 percent; Whites: census = 25 percent, study = 28 percent).

Consistent with other studies, we found elevated risks of squamous cell esophageal cancer for single men compared with married men (16–19), an inverse association with level of education (20–24), a greater risk for low status occupations compared with high status occupations (whether measured by job titles or educational requirements) (20, 21, 25), and an increased risk associated with incomes at or below the poverty level (26). In our study, adjustment for annual income reduced the magnitude and significance of the risks associated with other indicators of social class.

In addition, our study showed slight and nonsignificant excess risks for both Blacks and Whites associated with being born in the South compared with other regions of the United States. Overall, the percentage of case men born in the South was more than three times greater among Blacks than among Whites. The findings are consistent with data indicating that Southern-born Blacks are more disadvantaged economically than those born elsewhere (5). We also found elevated risks for subjects who reported visiting a dentist only rarely. This could reflect poor access to medical care due to poverty, oral infections, or social factors, such as purchases of alcohol and tobacco that took priority over dental care.

Although social class has been linked to squamous cell esophageal cancer in a number of studies (15, 19–22, 24–29), the underlying exposures or characteristics responsible for the association are unclear. Low social class is a surrogate for a set of lifestyle and other environmental factors including poor housing, unemployment or workplace hazards, limited access to medical care, stress, poor nutrition, and exposure to infectious agents (14). Some of these factors, such as nutritional status, may affect susceptibility to environmental carcinogens, but the mechanisms need to be clarified (29, 30).

Exposure to human papillomavirus, a sexually transmitted infectious agent associated with low social class (31, 32), has been suggested as a risk factor for squamous cell esophageal cancer (33, 34), but the epidemiologic data are not conclusive (35–40). Human papillomavirus seropositivity was found somewhat more often in Black male controls (6.3 percent) than in White male controls (4.6 percent) in our study population (41), but further studies are needed to determine whether this virus or other viruses play a role in esophageal cancer.

The strengths of our study include the use of population-based cases and controls; having large enough numbers of cases of each race to estimate risks for Blacks and Whites separately; the relatively high participation rate, considering the poor survival rates for esophageal cancer; the use of direct interviews; and the ability to conduct cell type-

specific analyses. Limitations include possible biases resulting from the tendency to interview cases with better survival; the potential for heightened recall among cases versus controls; the exclusion of subjects with missing data from the PAR analysis; and the problem of multiple comparisons and the possible influence of chance.

In summary, intake of moderate/heavy levels of alcohol, use of tobacco, infrequent consumption of raw fruits and vegetables, and low income were found to account for over 98 percent of the squamous cell esophageal cancer in this population and for 99 percent of the excess incidence among Blacks. The higher incidence rates observed among Blacks for exposure to the same risk factors as Whites may reflect a susceptibility state conditioned by genetic traits or by nutritional, viral, or other factors associated with low social class. Whatever the mechanism, it is clear that lifestyle modifications, including a reduction in alcohol and tobacco use and improvements in diet and living conditions, would markedly lower the incidence of squamous cell esophageal cancer in both racial groups. From a public health standpoint, our study suggests that the greatest impact would come from decreasing the levels of alcoholic beverage consumption, especially among the 13 percent of the population who are the heaviest drinkers. Further reductions in incidence would result from cessation of tobacco use. In addition, the independent effect of social class variables provides a clue for further research into viral, nutritional, metabolic, and environmental determinants that may be amenable to intervention.

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