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Article

Changes in Black-White Difference in Lung Cancer Incidence among Young Adults

Ahmedin Jemal, DVM, PhD,[1,*] Kimberly D. Miller, MPH,[1] Ann Goding Sauer, MSPH,[1] Priti Bandi, PhD,[1] Miranda M. Fidler-Benaoudia, PhD,[2,3] MaryBeth Culp, MPH,[1] Farhad Islami, MD, PhD,[1] Stacey A. Fedewa, PhD,[1] Jiemin Ma, PhD[1]

[1]Data Science, Office of the Chief Medical and Scientific Officer, American Cancer Society, Atlanta, GA, USA, [2]Department of Cancer Epidemiology and Prevention Research, Alberta Health Services, Edmonton, Alberta, Canada and [3]Departments of Oncology and Community Health Sciences, University of Calgary, Calgary, Alberta, Canada

Correspondence to: Ahmedin Jemal, DVM, PhD, American Cancer Society, 250 Williams St NW, Atlanta, GA 30303, USA (e-mail: ahmedin.jemal@cancer.org).

Abstract

Background: We previously reported that lung cancer incidence between Blacks and Whites younger than 40 years of age converged in women and approached convergence in men. Whether this pattern has continued in contemporary young birth cohorts is unclear. **Methods:** We examined 5-year age-specific lung cancer incidence in Blacks and Whites younger than 55 years of age by sex and calculated the Black-to-White incidence rate ratios (IRRs) and smoking prevalence ratios by birth cohort using nationwide incidence data from 1997 to 2016 and smoking data from 1970 to 2016 from the National Health Interview Survey. **Results:** Five-year age-specific incidence decreased in successive Black and White men born since circa 1947 and women born since circa 1957, with the declines steeper in Blacks than Whites. Consequently, the Black-to-White IRRs became unity in men born 1967-1972 and reversed in women born since circa 1967. For example, the Black-to-White IRRs in ages 40-44 years born between 1957 and 1972 declined from 1.92 (95% confidence interval [CI] = 1.82 to 2.03) to 1.03 (95% CI = 0.93 to 1.13) in men and from 1.32 (95% CI = 1.24 to 1.40) to 0.71 (95% CI = 0.64 to 0.78) in women. Similarly, the historically higher sex-specific smoking prevalence in Blacks than Whites disappeared in men and reversed in women born since circa 1965. The exception to these patterns is that the incidence became higher in Black men than White men born circa 1977-1982. **Conclusions:** The historically higher lung cancer incidence in young Blacks than young Whites in the United States has disappeared in men and reversed in women, coinciding with smoking patterns, though incidence again became higher in Black men than White men born circa 1977-1982.

Lung cancer is the leading cause of cancer death in the United States, with about 80% of the total 154 000 deaths recorded each year caused by cigarette smoking (1,2). Historically, lung cancer incidence rates have been higher in non-Hispanic Blacks (Blacks) than non-Hispanic Whites (Whites) among men of all ages and among younger women (3). This fact is thought to reflect the historically greater smoking prevalence in Black adults (4), as well as increased risk of lung cancer associated with tobacco carcinogens (5,6).

We previously reported that lung cancer incidence rates between Blacks and Whites ages 20-39 years by sex converged in women and that Blacks' rates approached Whites' rates in men based on incidence data from 1992 to 2006 from the 12 Surveillance, Epidemiology, and End Results (SEER) registries, covering about 14% of the US population (7). Whether this pattern has continued in contemporary young birth cohorts is unknown given the changing smoking patterns by race and sex. Further, the difference in early-onset lung cancer between Blacks and Whites by sex has not been examined at the national level. Herein, we concurrently examined national lung cancer incidence and cigarette smoking data to assess recent patterns of lung cancer incidence rates between Blacks and Whites by sex among contemporary young birth cohorts, and whether the incidence patterns are consistent with race- and sex-specific smoking patterns.

Methods

Data Source

We obtained invasive lung and bronchus cancer (lung cancer) cases diagnosed in ages 30-54 years between 1997 and 2016 in

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48 states and the District of Columbia from the Cancer in North America Database, covering 98% of the US population (8). Kansas and Maryland did not consent to participate. Race and ethnicityare categorized according to Hispanic origin as non-Hispanic Whites and non-Hispanic Blacks, hereinafter referred to as Whites and Blacks, respectively (9). We categorized age at diagnosis by 5-year age intervals (from 30-34 to 50-54 years) and year of diagnosis by 5-year calendar period (from 1997-2001 to 2012-2016). We classified lung cancer cases into 4 histological types using the third International Classification of Diseases for Oncology morphology codes as adenocarcinoma, squamous cell carcinoma, small cell carcinoma, and other specified (including large cell) and unspecified carcinomas (Supplementary Table 1, available online) (10-12).

Statistical Analysis

We used SEER*Stat software, version 8.3.5, to calculate age-specific incidence rates per 100 000 person-years by sex, race, and period. For each age- and period-specific group, we then calculated the Black-to-White incidence rate ratios (IRRs) with their 95% confidence intervals (CIs) using the Tiwari method, 2-sided P values ($\alpha = 0.05$) (13). We similarly examined the age-specific incidence and the Black-to-White rate ratios by birth cohort and histology. Birth cohort (year of birth) was determined by subtracting the midyear of age at diagnosis from the mid–calendar year of diagnosis, resulting in eight 10-year partially overlapping birth cohorts referenced by midyear of birth (1945-1980). To assess whether the main findings were affected by inclusion of state registries with missing data for any years during the study period, we performed a sensitivity analysis that included only 37 states that had data available for all study years. In supplementary analyses, we examined the Black-to-White incidence rate ratio for ages 30-49 years from 1997-2001 to 2012-2016 by state.

Based on the methods developed by Holford et al. (14), we calculated self-reported current and ever smoking prevalence and average number of cigarettes smoked per day by sex, age, race and ethnicity, year of survey, and birth cohort using the 1970-2016 National Health Interview Surveys (NHIS) (15). Briefly, current smoking prevalence was estimated as the product of ever smoking prevalence (≥100 cigarettes smoked in a lifetime) and cumulative probability of not quitting, which were obtained by age-period-cohort modeling of the probabilities of smoking initiation and cessation (quit smoking for ≥2 years) with adjustment for differential mortality. Similarly, the mean number of cigarettes smoked per day was estimated using cumulative logistic regression based on ordered categories of smoking intensity (<5, 5 to <15, 15 to <25, 25 to <35, 35 to <45, and ≥45 cigarettes), with the middle number (3, 10, 20, 30, 40, 60 cigarettes) of each category used for mean calculations. We also calculated the Black-to-White current and ever smoking prevalence ratios with their 95% confidence intervals by sex to assess whether the smoking prevalence between Blacks and Whites was statistically significantly different using SAS version 9.4 and bootstrapping for 95% confidence interval calculation with 1000 times of resampling.

Results

Figure 1 shows trends in 5-year age-specific lung cancer incidence (per 100 000 person-years) in Blacks and Whites aged 30-54 years by sex from 1997-2001 to 2012-2016 (actual values in Supplementary Table 2, available online). Among men, incidence rates generally decreased in both Blacks and Whites during the study period, with steeper declines in Blacks. Consequently, the Black-to-White IRR became unity (one) or approached unity (Supplementary Table 2, available online). An exception to this pattern was the increase in IRRs in ages 30-34 years and 35-39 years in 2012-2016 following convergence during the previous periods.

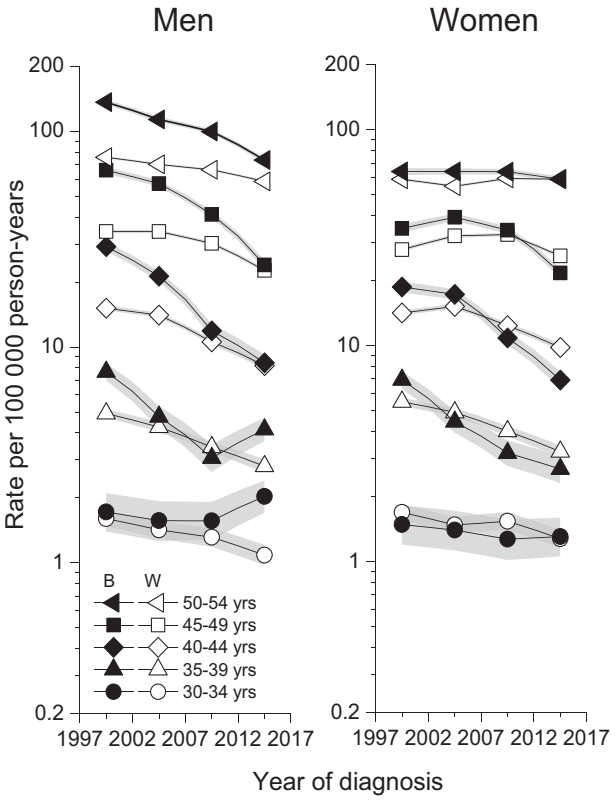

Figure 1. Age-specific lung cancer incidence rates in Whites and Blacks by sex and calendar year of diagnosis, 1997-2016. B = non-Hispanic Black; W = non-Hispanic White. Incidence rates are shown with 95% confidence intervals (shaded bands).

Among women, incidence rates during the study period declined in age groups 30-49 years in both Blacks and Whites, with the decline considerably larger in Blacks (Figure 1, Supplementary Table 2, available online). As a result, the Black-to-White IRR in these age groups reversed and became less than unity. For example, the Black-to-White IRR in women ages 45-49 years decreased from 1.25 (95% CI = 1.19 to 1.32) during 1997-2001 to 0.83 (95% CI = 0.79 to 0.88) during 2012-2016. Incidence rates in both Black and White women ages 50-54 years, however, decreased slightly or remained stable during the study period.

Figure 2 shows the same age-specific incidence rates for Blacks and Whites by sex plotted according to birth cohort (actual values in Supplementary Table 3, available online). Among men, incidence rates decreased in successive generations born since circa 1947, with a steeper decline in Blacks than Whites. Consequently, the Black-to-White IRRs among men became or approached unity. For example, among men ages 40-44 years, the incidence rate per 100 000 person-years in Blacks (29.2) was nearly twice as high as in Whites (15.2) born circa 1957 (IRR = 1.92, 95% CI = 1.82 to 2.03), but rates became similar

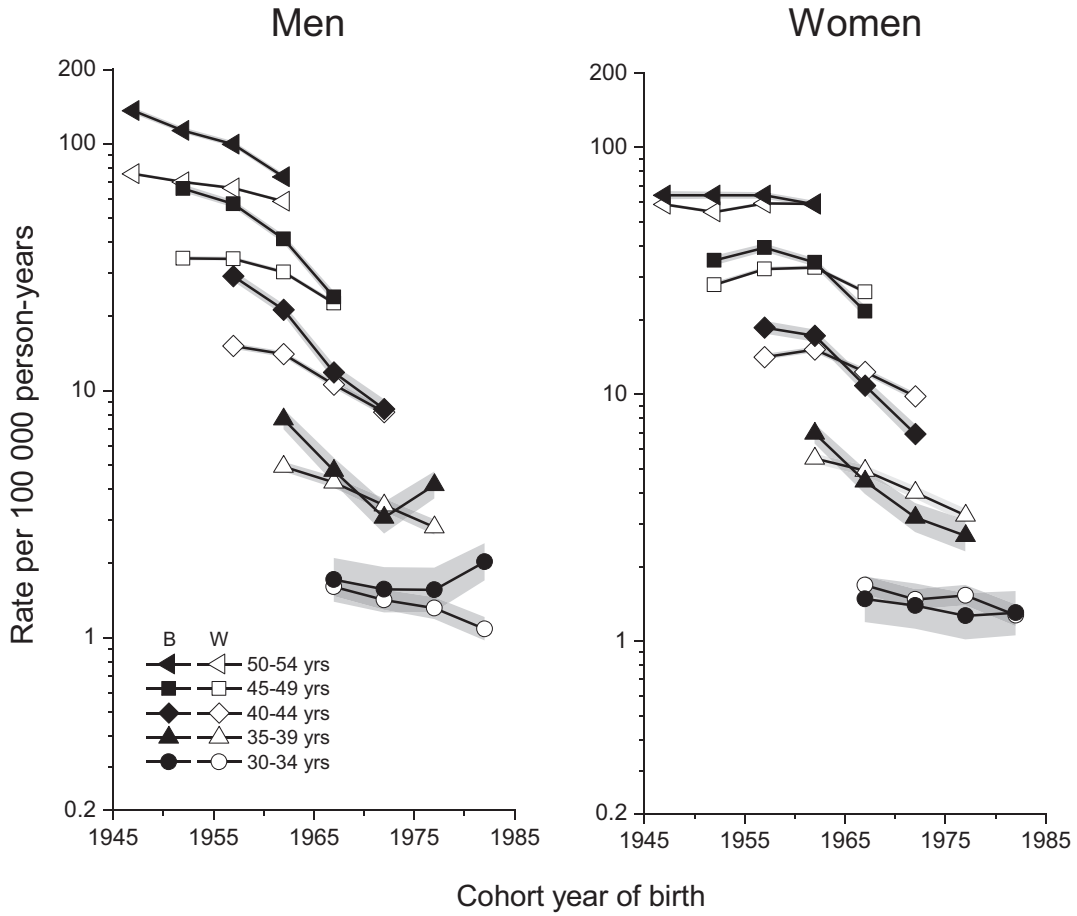

Figure 2. Age-specific lung cancer incidence rates in Blacks and Whites by sex and cohort year of birth, 1947-1982. B = non-Hispanic Black; W = non-Hispanic White. Incidence rates are shown with 95% confidence intervals (shaded bands).

between Blacks (8.4) and Whites (8.2) born circa 1972 (Black-to-White IRR = 1.03, 95% CI = 0.93 to 1.13) (Figure 3, Supplementary Table 3, available online). Age-specific incidence rates among Black men, however, increased in those born circa 1977 and 1982, resulting in a higher incidence rate in Black than White men born in those years (IRR = 1.87, 95% CI = 1.52 to 2.29; IRR = 1.48, 95% CI = 1.28 to 1.71, respectively).

Among women, incidence rates declined in Blacks and Whites born since circa 1962, with the declines again substantially larger in Blacks. Consequently, the Black-to-White IRRs became less than unity in those born since circa 1967. For example, among women ages 40-44 years, the Black-to-White IRR declined from 1.32 (95% CI = 1.24 to 1.40) in those born circa 1957 to 0.71 (95% CI = 0.64 to 0.78) in those born circa 1972 (Figure 3, Supplementary Table 3, available online). We found generally similar results when we restricted the analysis to the 37 states with data for all study years (Supplementary Table 4, available online).

Figure 4 shows the age-specific incidence rates in Blacks and Whites by histologic types and birth cohort (Supplementary Table 5, available online). The incidence trends for adenocarcinoma, squamous cell carcinoma, and small cell carcinoma generally follow the trends for all histologic types combined, with rates generally declining in successive younger men born since circa 1947 and women born since circa 1962. However, incidence rates for adenocarcinoma and for other specified and unspecified carcinoma increased in Black men born circa 1982. The Black-to-White IRRs by histologic types are presented in Supplementary Figures 1 and 2 (available online). The IRRs generally declined in successive younger men and women born after circa 1962 across all histologic types in both men and women, approaching or becoming unity with the exception of small cell carcinoma, for which rates were lower in Blacks than Whites across generations, especially among women.

Supplementary Table 6 (available online) depicts changes in lung cancer incidence rates from 1997-2001 to 2012-2016 in age 30-49 years by sex and state, as well as changes in Black-to-White IRR. In general, incidence rates during this period declined in Black and White men and women in all states, with the decline steeper in Blacks than in Whites. As a result, the Black-to-White IRR from 1997-2001 to 2012-2016 declined in both men and in women in most states.

Figure 5 portrays current-smoking prevalence for Blacks and Whites by age and sex plotted according to birth cohort (Supplementary Table 7, available online), with the corresponding Black-to-White smoking prevalence ratio given in Supplementary Figure 3 (available online). Among men, current-smoking prevalence declined in successive young birth cohorts in both Blacks and Whites, with the decline steeper in Blacks than in Whites. Consequently, the higher smoking prevalence in Black men than White men disappeared in those born since circa 1960. Similarly, smoking prevalence among women declined in successive young birth cohorts in both Blacks and Whites, with the decline considerably larger in Blacks than in

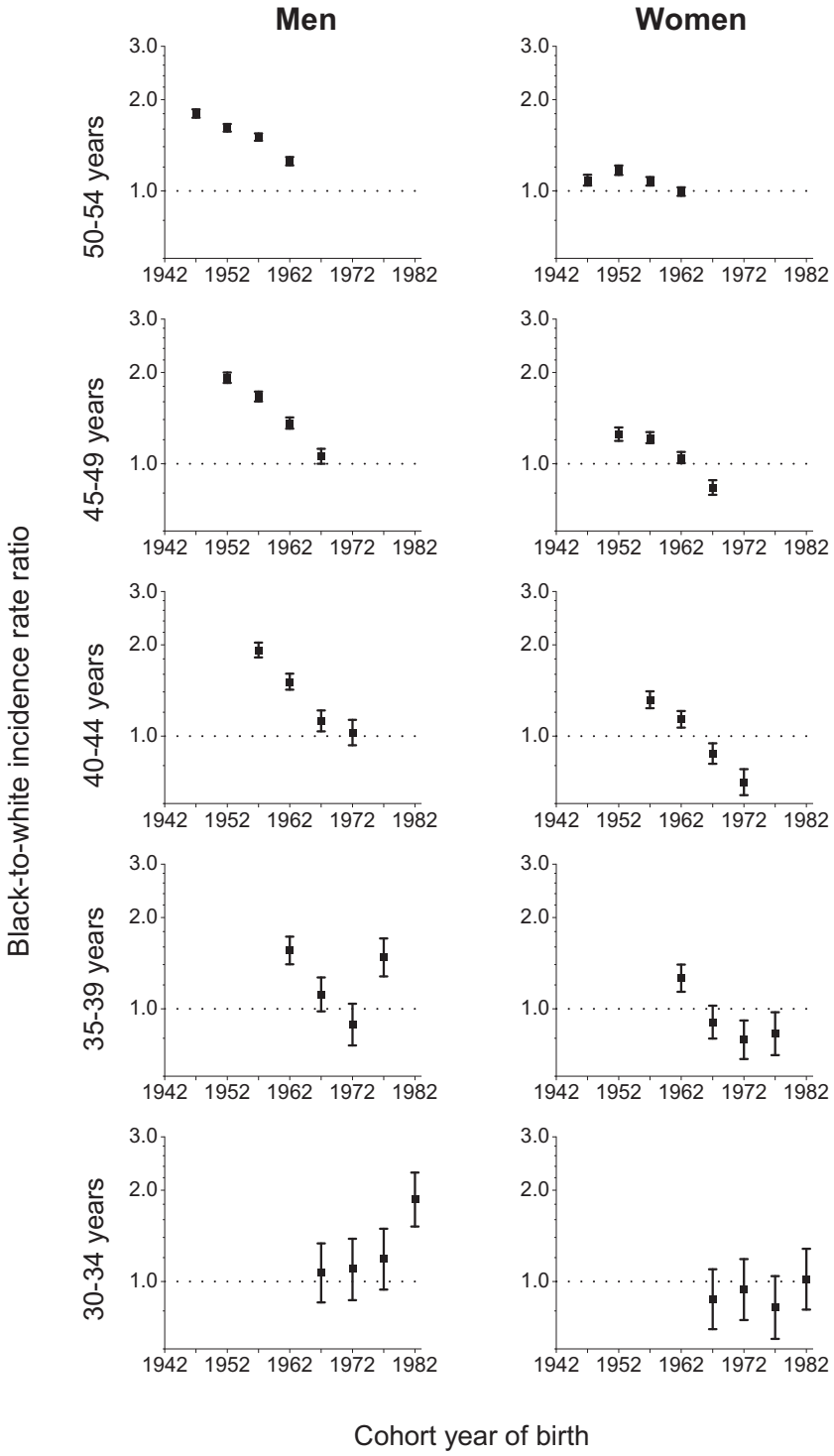

Figure 3. Age-specific Black-to-White lung cancer incidence rate ratios by sex and cohort year of birth, 1947-1982. Error bars indicate 95% confidence intervals.

Whites and the smoking pattern reversed in those born after 1960. For example, the Black-to-White smoking prevalence ratios among women ages 40-44 years changed from 1.23 (95% CI = 1.18 to 1.29) in those born in 1955 to 0.75 (95% CI = 0.71 to 0.84) in those born in 1970 (Supplementary Table 7, available online).

Supplementary Figure 4 (available online) shows the average number of cigarettes smoked per day for White and Black men and women by birth cohort. Number of cigarettes smoked per day decreased in successive generations born since circa 1930 in White and Black men and women. But number of cigarettes smoked per day continued to be lower in Blacks than in Whites in both men and in women across all generations.

Discussion

Our primary findings are that the historically higher early-onset lung cancer incidence rates in Blacks than Whites have

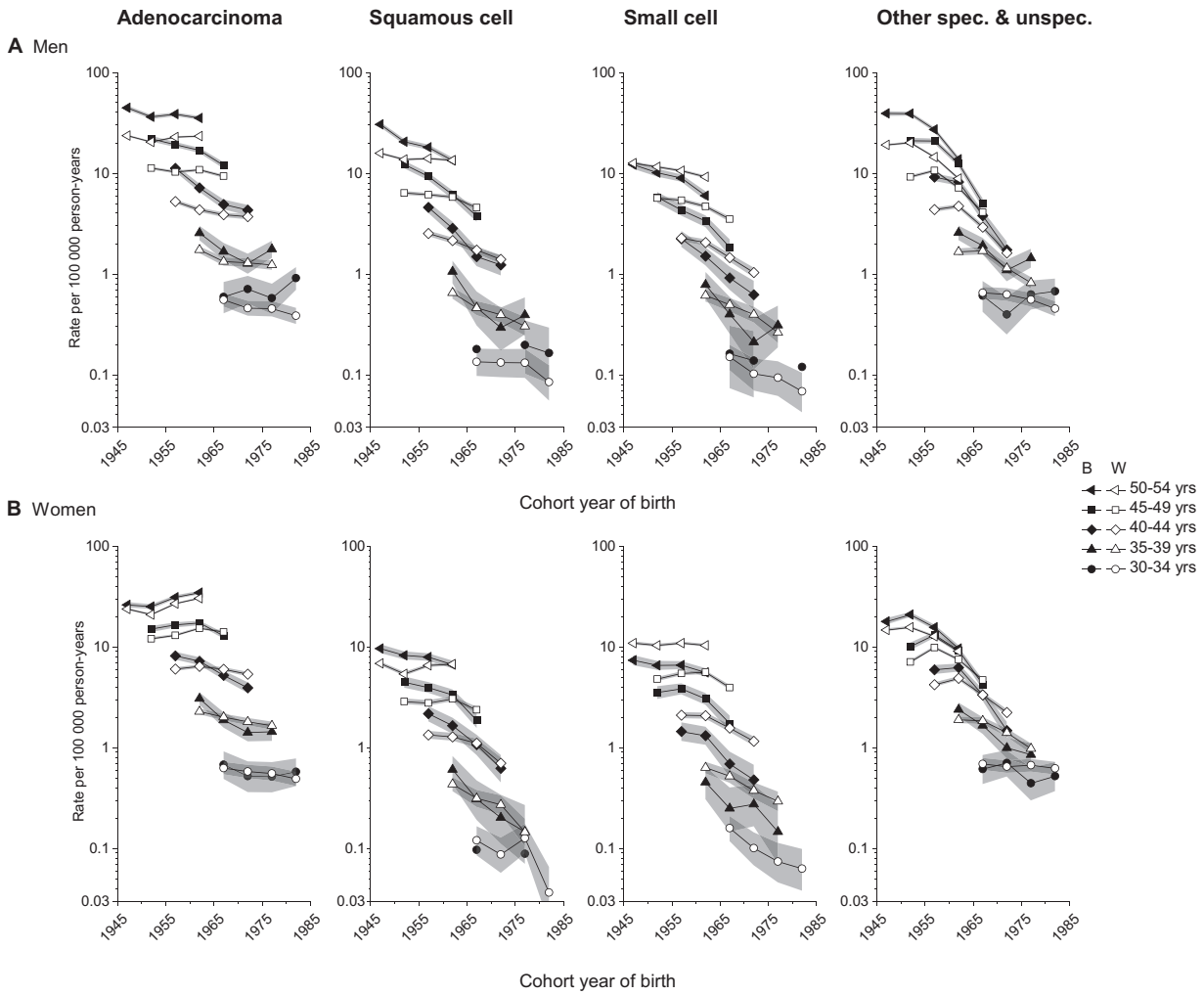

Figure 4. Age-specific lung cancer Black-to-White incidence rates by sex, histology, and cohort year of birth. B = non-Hispanic Black; W = non-Hispanic White. Incidence rates are shown with 95% confidence intervals (shaded bands) and are suppressed when based on fewer than 6 cases. Other and unspecified includes large cell tumors.

disappeared in men born circa 1967-1972 and reversed in women born since circa 1967. Consistent with these patterns, the historically higher smoking prevalence in Blacks than Whites disappeared in men and reversed in women born since the 1960s. The exception to these patterns was the higher lung cancer incidence rate in Black men compared to White men born circa 1977-1982, which was not explained by smoking prevalence.

The more rapid decline in adult smoking prevalence in Blacks than Whites born after the 1960s likely reflects the precipitous decline in cigarette smoking initiation among Black teenagers from the late 1970s to early 1990s. For example, among 12th graders, current-smoking prevalence between 1977 and 1992 decreased from 36.7% to 8.1% among Blacks compared with from 38.3% to 31.8% among Whites (16). This more favorable trend in Black adolescents is thought to be due to greater sensitivity to increased cigarettes prices (17), stronger parental and community nonsmoking norms (18), greater perception of the health hazard of smoking, and increased participation in sports (19).

Another notable finding of our study is the increasing lung cancer incidence rates in Black men born circa 1977-1982, leading to higher lung cancer incidence rates in Black than White men born during this period. This increase likely reflects the steep rise in initiation of smoking among Black adolescents in the 1990s, which coincided with the R.J. Reynolds tobacco advertisement campaign targeting African Americans (20). Between 1991 and 1997, the prevalence of current cigarette use among Black high school students doubled from 14.1% to 28.2% (21).

The higher lung cancer incidence rate in Black men than White men born circa 1977-1982 was largely driven by adenocarcinoma, the majority of which is caused by cigarette smoking similar to other histologic types (22,23). However, this excess risk could not be explained by racial differences in smoking patterns in men born circa 1980, as current adult smoking prevalence is generally similar between Blacks and Whites (Figure 5 and Supplementary Table 7, available online) and the number of cigarettes smoked per day is lower in Blacks (Supplementary Figure 4, available online). Also, there is no evidence that menthol cigarettes, which are more commonly smoked among Blacks, are more carcinogenic than non-menthol cigarettes (24,25). It is possible, however, that the higher lung cancer rates in Black men may reflect an increased risk of the disease associated with cigarette smoking (5, 6). For example, Stram et al. reported that the risk of lung cancer among current smokers of less than 20 cigarettes per day is about twice as high in Blacks

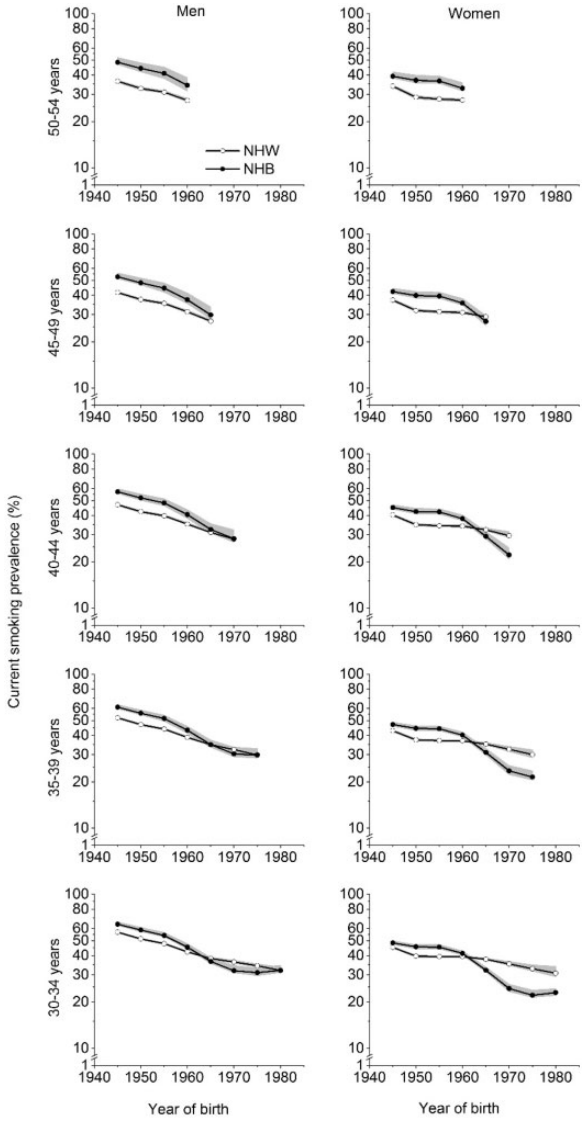

Figure 5. Age-specific current smoking prevalence (%) by sex and birth cohort, 1945-1980. Shaded bands indicate 95% confidence intervals.

as in Whites (5). Although the underlying mechanisms driving the increased risk are unknown, serum cotinine levels among smokers have been shown to be considerably higher in Blacks than Whites or Mexican Americans at each level of cigarette smoking (5), as are total nicotine equivalent levels in urine (26). Thus, it may be that lung exposure to tobacco carcinogens is higher in Black than White smokers. It may also be that Blacks are constitutionally more susceptible to the effects of tobacco carcinogens (5,6).

Racial differences in current smokeless tobacco and cigar use cannot explain the higher lung cancer rates in Black men than White men born circa 1982, as they are considerably lower in Blacks than in Whites (27). Exposures other than active tobacco use, such as secondhand smoke and air pollution, are more prevalent in Blacks than in Whites (28,29). The contribution of these factors to the higher lung cancer rates in young Black men, however, is likely to be small as 80% of lung cancer patients aged under 40 years are current or former smokers (30,31) and the lung cancer rate in Black men is nearly double that of White men (Supplementary Table 3, available online).

Our findings have public health implications. On one hand, the elimination or reversal of the disparity in early-onset lung cancer incidence rates among Blacks avoids the undue suffering, morbidity, and premature deaths associated with the disease. Moreover, it reflects the success of national, state, and local antitobacco public health policies and activities in the Black community despite the tobacco companies' targeted and deceptive marketing strategies (20,32). On the other hand, the increase in the incidence rates among Black men born circa 1982 attests the lack of strong public health policies to prevent the rise in smoking initiation in the 1990s. Further, it foreshadows the rising burden of lung cancer and other smoking-related diseases at older ages among Black men and calls for intensified and targeted interventions to promote smoking cessation in this vulnerable population. Such interventions include clinicians' recommendation and counseling to quit smoking, treatment for tobacco dependence (33), and public policies targeting social determinants of health such as poverty and lack of insurance for accessing high-quality care and for handling stress (34).

A strength of our study is the use of nationwide, high-quality population-based data on both lung cancer incidence and smoking. However, our study has several limitations. First, interpretation of our findings by histologic subtype could be affected by improvements in histological classifications as unknown histological types are increasingly classified as adenocarcinoma or squamous cell carcinoma because of advances in the molecular characterization of the disease (35). However, this will not affect the interpretation of our findings based on the overall lung cancer incidence rates. Second, we could not present incidence rates for overlapping birth cohorts narrower than 10 years because lung cancer occurs less frequently in young men than allows for calculation of more stable rates. Third, cancer registries do not collect individual-level smoking information; thus, we could not directly measure the contribution of smoking to the emerging lung cancer incidence rates in Blacks versus Whites. Fourth, we used self-reported cigarette smoking from NHIS to compare smoking prevalence between Blacks and Whites at the national level, which may be subject to racial differences in social desirability bias. According to data from National Health and Nutrition Examination Surveys, however, there was little difference between biochemically assessed and self-reported smoking prevalence by race and age (36). Fifth, the NHIS excludes institutionalized populations in which Blacks and smokers are overrepresented. According to one study, however, the difference between incarceration-corrected and uncorrected national smoking prevalence among Black men was small (2.1%) (37). Sixth, because of sparse data for certain groups in the NHIS, we used modeled smoking prevalence, with uncertainties from survey samples and the model, rather than observed prevalence. The model overestimated the prevalence for ages 30-39 years, but the overestimate was nondifferential between Blacks and Whites. Finally, our analysis did not consider the changing pattern of e-cigarettes, which entered the US market in the late 2000s. There is little evidence, however, that there has been a shift from cigarettes to e-cigarettes among adults aged 25-44 years (38).

In conclusion, the historically higher lung cancer incidence rates in Blacks than Whites among young adults have disappeared in men born 1967-1972 and reversed in women born

since circa 1965, which are consistent with the generational changes in smoking prevalence between Blacks and Whites by sex. Although these patterns herald progress in reducing racial disparities in lung cancer occurrence and the success of tobacco control in the Black community, the increasing lung cancer incidence rates in Black men born circa 1977-1982 is concerning and underscores the need for targeted tobacco prevention interventions.

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Notes

Role of the funder: The American Cancer Society had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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Role of the authors: AJ: Conception and design. All authors: Data acquisition, analysis, and interpretation. AJ: Drafted initial manuscript. All authors: Drafting, revising, editing manuscript.

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