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Short Report

Pesticide Use and Pesticide-Related Symptoms Among Black Farmers in the Agricultural Health Study

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Background *Health effects of pesticides have not been well studied in black farmers. We describe agricultural practices and pesticide-related symptoms in North Carolina black and white farmers participating in the Agricultural Health Study.*
Methods *Self-administered questionnaires were completed by 891 black and 11,909 white farmers licensed to apply restricted pesticides. Regression models were used to compare characteristics by race.*
Results *Black farmers reported lower lifetime pesticide use, less use of each class of pesticides (e.g., herbicides, insecticides), less use of high exposure application methods, and fewer pesticide-related symptoms such as headaches or dizziness, skin irritation, chest discomfort and feeling nervous or depressed than did white farmers.*
Conclusions *Differences between black and white farmers may be explained by farm characteristics or economics. Despite lower use of pesticides, black farmers may have other work practices that affect exposure and risk.* Am. J. Ind. Med. 41:202–209, 2002. *Published 2002 Wiley-Liss, Inc*†

KEY WORDS: African Americans; farmers; pesticides; exposure; health; occupational disease

INTRODUCTION

Exposure to pesticides has increased due to widespread application in agricultural and environmental pest control [Fleming et al., 1999]. Farmers have numerous opportunities for exposure to pesticides, including during planting and cultivation of crops, pesticide application to crops, livestock, and storage areas, mixing and preparing pesticides for application, and loading and cleaning application equipment [Perry and Layde, 1998]. Farmers may be at greater risk for pesticide exposure if they incorrectly handle,

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store, or dispose of pesticides or if they do not wear personal protective gear [Winstead, 1993]. Farmers may therefore be at higher risk for acute and chronic health effects associated with pesticides.

The characteristics of pesticide use and its impact on acute and chronic health effects among white farmers are either well documented or currently being studied [Blair and Zahm 1993; Perry and Layde 1998; Fleming et al., 1999]. However, little or no data are available on black farmers due to their small numbers [Delzell and Grufferman, 1985; Winstead, 1993; Arcury, 1997]. This paper describes the pesticide use profile and occurrence of pesticide-related health symptoms among black farmers as compared to white farmers who are part of a large cohort of licensed pesticide applicators.

MATERIALS AND METHODS

The Agricultural Health Study (AHS), a prospective study of licensed pesticide applicators from Iowa and North Carolina, is a collaborative effort involving the National Cancer Institute, the National Institute of Environmental Health Sciences, and the US Environmental Protection Agency (EPA). A detailed description of the study methods has been published [Alavanja et al., 1996]. Briefly, participants were identified during certification classes for pesticide licensing. A self-completed enrollment questionnaire collected information on demographic characteristics, lifestyle activities, exposure to 50 pesticides, methods and types of pesticide use, farm characteristics, use of protective gear, and limited data about health symptoms and medical care related to pesticide use.

Between 1994 and 1997, 24,878 private applicators attended certification classes for restricted pesticide licensing in North Carolina (NC) and approximately 83% (n = 20,528) enrolled in the AHS. According to the 1997 Census of Agriculture, there were 49,406 farmers in NC. Licensed private applicators (who are licensed on a 3-year cycle) represent 42% of this total.

For this analysis, data on Iowa farmers were not included due to the very small number of black farmers in that state. AHS private applicators also were excluded if their gender was female (917) or not given (1) or if self-defined race was missing or not either black or white (1,950). Whites of Hispanic origin (168) also were excluded. Private applicators who lived in the mountain region (western part) of NC were excluded from the analysis because of the small number of enrolled black applicators from that region; 23 blacks and 4,137 whites were excluded. Applicators were also excluded if region of residence was not known (13 blacks and 94 whites), if information on ever mixing or applying pesticides was missing (44 blacks and 85 whites), if the licensee reported never mixing or applying pesticides (31 blacks and 71 whites), and if the applicator did not report engaging in farm work (13 blacks and 181 whites). Thus, 62.4% of the NC private applicators enrolled in the AHS were included in this analysis; 891 blacks and 11,909 whites.

Exposure Measures

Cumulative pesticide exposure for a farmer in *pesticide-days* was estimated by multiplying the average number of days per year by the average number of years of pesticide use. Pesticide application methods that could result in a high level of direct exposure to the farmer (airblast, hand-spray gun, backpack sprayer, mist blower/fogger, powder duster, pouring fumigant, dipping animals in pesticides, spraying animals, or pouring pesticides on animals) were defined as *high exposure methods*. Other direct and indirect measures of exposure included type of pesticide used (grouped by class of pesticide such as herbicides or insecticides, or individually), the percent of time required pesticides were personally mixed or applied by the participant, use of protective gear, and application method.

Health Measures

Health effects reported here are based on the responses to two sets of questions on the enrollment questionnaire. The first asked, ''How often, if ever, have you had the following symptoms that you think may be related to your using pesticides?'' Seven symptoms were listed and respondents could answer ''never or rarely,'' ''sometimes,'' or ''frequently/almost always.'' Respondents also were asked, ''As a result of using pesticides, how often have you seen a doctor [....been hospitalized]?'' Response categories were never, once, twice, or three or more times.

Analysis

Racial differences were investigated by comparing adjusted means calculated using linear regression. To improve normality, cumulative pesticide-days, and number of pesticides used were log transformed. For categorical variables, racial differences were investigated by calculating crude and adjusted odds ratios (OR) using logistic regression. One set of models was used for comparing demographic characteristics, lifestyle activities, farming characteristics, application method, and protective gear use. Covariates considered were age, region (Piedmont, Coastal), and education (< high school, high school graduate, > high school). Logistic models were used for pesticide exposure characteristics, health symptoms, and medical attention sought related to pesticide use with the covariates listed above and with the additional covariates cumulative pesticide-days and smoking.

RESULTS

Although the mean ages of black and white farmers were similar (48.9 years vs. 48.0 years after adjusting for

TABLE I. Demographic and Lifestyle Characteristics of Black and White Male Farmers Participating in the Agricultural Health Study, North Carolina, 1994–1997

	Black (n = 891) percentage yes	White (n = 11,909) percentage yes	OR	95% CI
Region[a]				
Piedmont	19.1	35.9	1.00	Referent
Coastal	80.9	64.1	2.42	2.04–2.88
Age at enrollment[a]				
< 35	16.7	18.5	1.00	Referent
35–54	49.4	47.3	1.24	1.02–151
55–74	29.6	31.9	1.12	0.91–1.38
≥ 75	4.3	2.3	2.39	1.63–3.49
Educational level[b]				
< High school	41.2	14.4	1.00	Referent
High school	35.2	46.1	0.26	0.22–0.31
> High school	23.6	39.5	0.20	0.17–0.24
History of cigarette smoking[c]	58.5	59.6	0.79	0.68–0.93
Cigarettes per day (former and current smokers)[c]				
≤ 10	41.4	21.2	1.00	Referent
11–20	45.8	38.2	0.58	0.46–0.73
> 20	12.8	40.6	0.15	0.11–0.21

[a]Adjusted for age or region.
[b]Adjusted for age and region.
[c]Lifestyle characteristics adjusted for age, region, and education.
OR, odds ratio (Black vs. White); CI, confidence interval.

region of residence), twice as many blacks as whites were over age 75 at enrollment (Table I). Black farmers were less well educated. After adjusting for age, region, and education, blacks were less likely to report a history of cigarette smoking (OR = 0.79, CI = 0.68–0.93) or to smoke heavily. Smoking is more prevalent in Coastal North Carolina. After stratifying by region, differences in smoking remained. The adjusted OR was 0.82 in the Coastal region and 0.72 in the Piedmont.

The percentage of black and white farmers who raised any farm animals or produced any crops in the last year did not differ (Table II). White farmers, however, reported raising significantly more livestock, planting more acres, and cultivating more grain, hay and soybeans than did black farmers. Black farmers produced significantly more peanuts and potatoes than did white farmers.

At every age, black farmers reported less lifetime pesticide use than did white farmers (Fig. 1). The mean cumulative number of pesticide-days and standard deviation (SD) was 389.8 ± 656.6 for black farmers as compared with 623.5 ± 962.9 for white farmers ($F = 160$, $P < 0.001$ after adjusting for age, region, and education).

Total number of years of farming was not reported on the enrollment questionnaire. Therefore, in order to determine if the difference between blacks and whites in years of pesticide exposure was due to fewer years of farming, a subset analysis was conducted among the 40% of farmers with data from a more detailed take-home questionnaire. Black farmers reported fewer years of farming than did whites but this did not entirely explain their lower cumulative pesticide exposure (Table III).

Black farmers reported less use of each class of pesticides than did white farmers (Table IV), with blacks reporting past use of an average of 8 ($SD = \pm 6.8$) different pesticides as compared to 14 ($SD = \pm 8.0$) for white farmers ($F = 355$, $P < 0.001$ after adjusting for age, region, education, and pesticide-days). Black farmers more often reported that when pesticides were needed, they personally did the mixing or applying less than half the time. Furthermore, black farmers were less likely to report using high exposure application methods. Although black farmers were more likely to report using some forms of protective gear, they were less likely to report using chemically resistant gloves (OR 0.55, CI = 0.45–0.66) (Table IV).

Black farmers less often reported six of seven health symptoms potentially attributed to pesticide use (Table V). Most farmers (92%) had not sought medical care as a result of using pesticides; the difference between blacks and whites was negligible. With only one exception, the odds ratios for health symptoms and seeking medical attention for

TABLE II. Farm Characteristics in the Year Prior to Enrollment of Black and White Male Farmers Participating in the Agricultural Health Study, North Carolina, 1994–1997

	Black (n = 891) percentage yes	White (n = 11,909) percentage yes	OR[b]	95%CI
Livestock or poultry raised in the last year				
Raised any livestock or poultry in the last year	9.5	10.7	0.98	0.75–1.29
Fifty or more poultry at one time the last year[a]	8.6	9.0	0.90	0.66–1.23
Fifty or more livestock at one time in the last year[a]	15.4	25.3	0.60	0.47–0.76
Crops produced in the last year				
Produced any crops in the last year	81.4	81.3	0.84	0.67–1.04
Grain	22.1	36.8	0.50	0.41–0.61
Hay	0.6	3.7	0.25	0.08–0.78
Orchard fruit (apples and peaches)	1.0	1.3	0.86	0.37–1.99
Other fruit	1.9	1.9	1.08	0.59–1.97
Vegetables	16.7	13.8	1.21	0.97–1.51
Cotton	22.3	19.3	0.99	0.81–1.21
Christmas trees	0.9	0.9	1.27	0.54–2.95
Peanuts	33.6	16.7	2.00	1.67–2.41
Tobacco	50.3	50.5	0.90	0.76–1.05
Soybeans	62.4	60.9	0.80	0.67–0.95
Potatoes	7.7	4.5	1.48	1.06–2.05
Fifty or more acres planted in the last year	63.4	72.2	0.55	0.46–0.66

[a]Among those who raised livestock or poultry.
[b]Adjusted for age, region, and education.
OR, odds ratio (Black vs. White); CI, confidence interval.

pesticide exposure related symptoms were not altered by adjusting for cumulative pesticide-days (data not shown). After adjustment, there was no longer a difference between blacks and whites in the percentage who reported eye irritation (OR = 0.98, CI = 0.77–1.23).

DISCUSSION

Black farmers tended to use fewer types of pesticides and use them less frequently than their white counterparts. Blacks also reported fewer pesticide-related health symptoms than did whites, but this was not explained by their fewer cumulative days of pesticide exposure. Since applicators were asked how often they had specific health symptoms that they thought might be related to their use of pesticides, responses may have been influenced by their perception of whether these symptoms were the result of pesticide exposure. It is conceivable that, after taking into account days of pesticide use, blacks experienced as many symptoms as whites, but were less likely to attribute these to their use of pesticides. This would be consistent with the fact that there was no difference in seeking medical attention as a result of pesticide exposure.

AHS farmers are younger than the general population of all NC farmers and a greater proportion (84%) had at least a high school education [US Department of Commerce, Bureau of the Census, 1998, 1999]. These differences likely reflect the fact that the cohort was limited to the subset of farmers who obtain a license for use of restricted pesticides.

The greater variety and amount of pesticide exposure reported by white farmers in NC than by black farmers may reflect differences in farm size, farm type, years of farming, and operational needs. Previous studies suggest that farmers base decisions regarding pesticide use on operational needs [Blair and Zahm 1993], thus they may not use pesticides in all years of farming. This may be more likely to be the case for black farmers or those with smaller operations who may tend to have more variety in crops raised over the years. The difference in pesticide exposure also may be explained by economics.

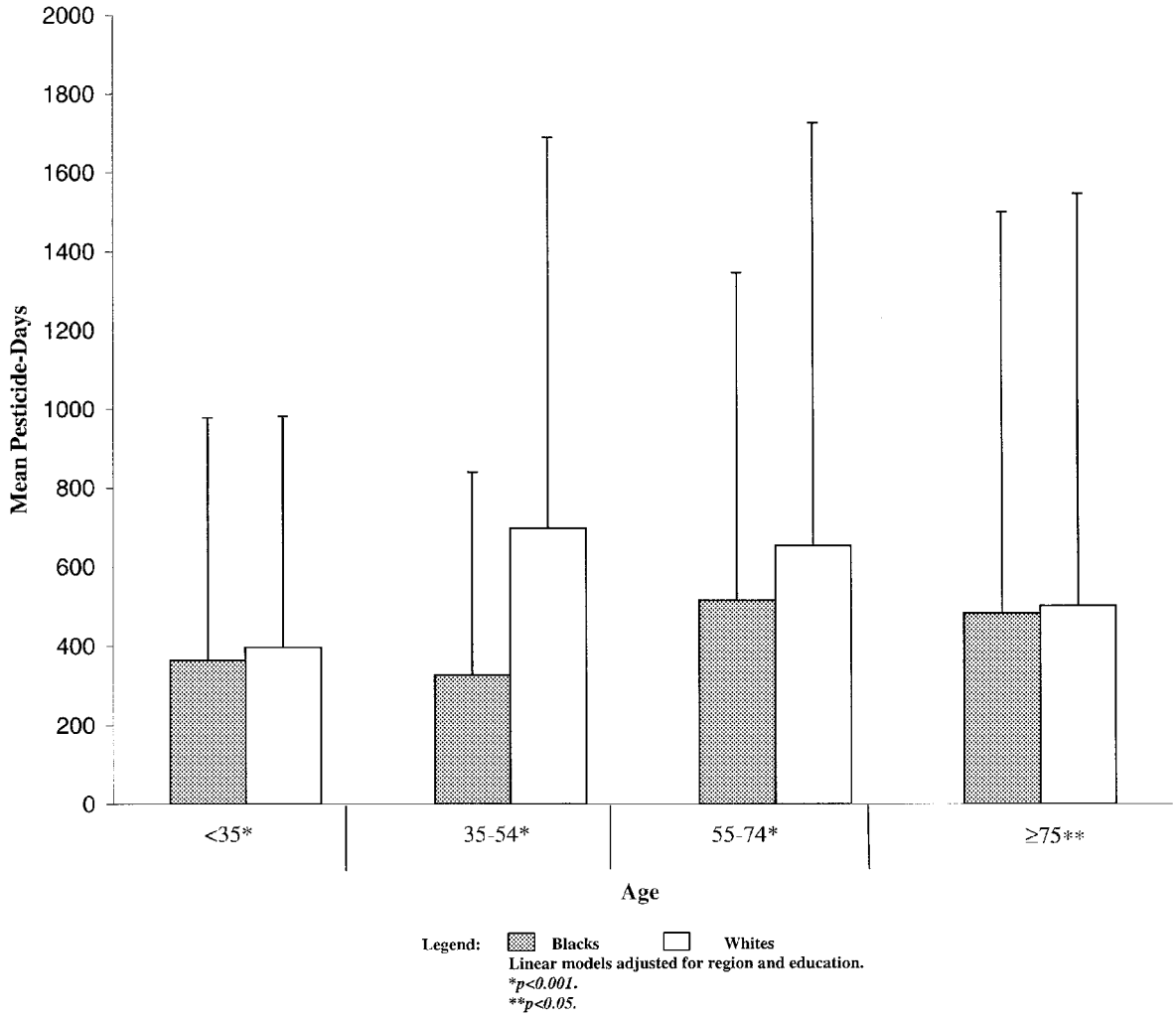

FIGURE 1. Average cumulative pesticide exposure and standard deviation by age of black and white male farmers participating in the agricultural health study, North Carolina, 1994–1997.

TABLE III. Farm Years and Cumulative Pesticide Exposure of Black and White Male Farmers Who Completed the Take-Home Applicator Questionnaire of the Agricultural Health Study, North Carolina, 1994–1997

	Black (n = 268) percentage yes	White (n = 4,751) percentage yes	OR	95% CI
Years lived or worked on a farm[a]				
≤ 10 years	6.6	5.6	1.00	Referent
11–20 years	14.7	8.7	1.43	0.76–2.69
20–30 years	19.7	14.4	1.06	0.58–1.94
>30 years	59.1	71.3	0.62	0.36–1.07
Cumulative pesticide exposure (pesticide-days)[b]				
< 150	48.3	33.6	1.00	Referent
150–499	31.3	34.3	0.70	0.49–0.99
500–1,499	16.4	24.3	0.47	0.30–0.75
≥ 1,500	4.0	7.8	0.36	0.17–0.77

[a]Adjusted for age, region, and education.
[b]Adjusted for age, region, education, and farm years.
OR, odds ratio (Black vs. White); CI, confidence interval.

TABLE IV. Pesticide Exposure Characteristics of Black and White Male Farmers Participating in the Agricultural Health Study, North Carolina, 1994–1997

	Black (n = 891) percentage yes	White (n = 11,909) percentage yes	OR[a]	95% CI
Class of pesticide used				
Herbicides	77.1	88.7	0.49	0.38–0.61
Insecticides	58.4	85.7	0.28	0.23–0.34
Fumigants	2.6	9.8	0.40	0.26–0.62
Fungicides	23.3	32.6	0.82	0.68–0.99
Percent of time personally mix pesticides				
≥ 50%	53.0	74.7	1.00	Referent
< 50%	47.0	25.3	2.15	1.81–2.52
Percent of time personally apply pesticides				
≥ 50%	57.7	77.3	1.00	Referent
< 50%	42.3	22.7	2.12	1.78–2.55
Application method				
No high exposure method	41.4	15.3	1.00	Referent
High exposure method	58.6	84.7	0.31	0.26–0.38
Types of protective gear generally used				
Ever used protective gear	89.8	82.3	2.17	1.62–2.90
Cartridge respirator or gas mask	17.6	20.7	1.09	0.86–1.37
Face shields or goggles	54.0	48.5	1.48	1.23–1.78
Disposable outer clothing	10.8	11.2	1.13	0.85–1.50
Fabric/leather gloves	37.2	28.6	1.48	1.22–1.79
Chemically resistant gloves	43.3	63.5	0.55	0.45–0.66
Other protective clothing	31.6	36.7	0.92	0.76–1.12

[a]Adjusted for age, region, education, and pesticide-days.
OR, odds ratio (Black vs. White); CI, confidence interval.

Overall, the majority of NC AHS farmers reported ever using some type of protective gear. Because the questionnaires were completed during licensing classes, use of protective equipment may have been over-reported. Some farmers may have mistakenly feared, for example, that not reporting good handling practices might jeopardize their license. Differences in self-reported use of protective gear also may reflect differences in the accuracy of the self-reports by blacks and whites. Black applicators had fewer years of education, which may have contributed to difficulties in completing the questionnaire. Adjusting for education did not affect results. On the other hand, if as reported by the field teams, blacks were more likely to rely on help from the Agricultural Extension Agents, they may be more likely to use recommended pesticide handling practices. Furthermore, these differences could also reflect their more recent entry into farming.

Although black farmers reported more use of protective gear, some of their protective practices are not thought to be especially effective. Use of fabric or leather gloves, for example, may actually increase pesticide exposure if gloves become saturated with pesticides. Blacks were less likely to report using chemically resistant gloves, which afford the greatest degree of protection but are substantially more costly than other gloves. Of course, if blacks were using less toxic chemicals, strict protective measures may not have been recommended.

The response rate for all NC private applicators (83%) compares favorably with the response rates achieved by other prospective cohort studies which generally have enrollment rates below 70% [Alavanja et al., 1996]. More awareness of pesticide related health risks, the ability to complete the questionnaire at the licensing center, or the assumption that the questionnaire was part of the licensing application may have contributed to this high response rate. Although the race-specific response rate can not be determined, since the race category was eliminated from the NC licensing application, onsite observation suggested that the response rate was similar or even somewhat higher for black farmers [J Pierce, personal communication]. Other strengths of the study include the large amount of information on pesticide use and farming characteristics and the large number of white and black farmers participating. Although many black farmers are reported to be leaving farming [Zabawa et al., 1994], this study includes one of the largest cohorts of black male pesticide applicators ever studied.

TABLE V. Self-Reported Symptoms and Medical Care Related to Pesticide Use of Black and White Male Farmers Participating in the Agricultural Health Study, North Carolina, 1994–1997

	Black (n = 891) percentage	White (n = 11,909) percentage	OR[a]	95% CI
Self-reported symptoms believed to be related to personal pesticide use				
Excessively tired				
Never/rarely	84.7	85.1	1.00	Referent
More than rarely	15.3	14.9	1.07	0.85–1.34
Headaches/dizziness				
Never/rarely	81.4	72.4	1.00	Referent
More than rarely	18.6	27.6	0.62	0.50–0.77
Nausea/vomiting				
Never/rarely	93.7	92.0	1.00	Referent
More than rarely	6.3	8.0	0.76	0.53–1.08
Skin irritation				
Never/rarely	85.5	79.5	1.00	Referent
More than rarely	14.5	20.5	0.71	0.56–0.90
Eye irritation				
Never/rarely	82.1	77.7	1.00	Referent
More than rarely	17.9	22.3	0.84	0.67–1.04
Chest discomfort				
Never/rarely	93.3	91.3	1.00	Referent
More than rarely	6.7	8.7	0.65	0.46–0.93
Nervous/depressed				
Never/rarely	90.9	88.2	1.00	Referent
More than rarely	9.1	11.8	0.71	0.53–0.95
Sought medical care				
Never	91.1	92.1	1.00	Referent
Once or more	8.9	7.9	1.05	0.79–1.39

[a]Adjusted for age, education, smoking, and region.
OR, odds ratio (Black vs. White); CI, confidence interval.

This study has some limitations. The selection method may not have captured a representative group of farmers, particularly black farmers, with significant current and historical pesticide exposure. Some farmers may be unable to obtain their own license because they are illiterate or due to other barriers, while others may not obtain a license because a fellow licensed farmer can provide them with access to pesticides. Thus, the finding that blacks in the AHS had lower cumulative self-reported pesticide exposure than whites may not be generalizable to farmers who do not obtain a pesticide license but still apply pesticides. Farmers can be expected to accurately recall details of their use of pesticides because it is a significant part of their farming operation [Brown et al., 1990]. However, AHS farmers may have left responses deliberately blank because they considered such information private. The quality of the self-reports may vary with race and other factors that differed by race. Moreover, the responses for health symptoms may be biased because we asked farmers if they experienced symptoms or required medical attention because of their pesticide use. Some farmers may fail to link symptoms to pesticide use or fail to report exposure-linked symptoms for fear of appearing to be handling pesticides improperly.

Black farmers in the NC AHS cohort reported less cumulative exposure to pesticides. It remains to be seen if this translates to lower risk for pesticide-associated health effects in the future or if other aspects of the farm experience of black pesticide applicators places them at increased risk for acute and chronic health effects related to pesticide use.

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