

The Epidemiology of Tuberculosis Among North Carolina Migrant Farm Workers

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Although tuberculosis (TB) has been recognized as a significant health problem of migrant farm workers, the nature and extent of the problem have been poorly defined. We report the first population-based study of TB in a random sample of farm workers (n = 543) and the first use of recall antigens in an epidemiologic study of TB. Purified protein derivative positivity ranged from 33% in Hispanics to 54% in US-born blacks and 76% in Haitians. Active tubercular disease occurred in 3.6% of US-born blacks and 0.47% of Hispanics. Among US-born blacks, risk factors associated with farm work were most significant. Blacks born in the United States also had the highest prevalence of anergy. The use of recall antigens made possible a better description of the epidemiology of TB by excluding false negatives and clarifying associations between infection and risk factors. We conclude that TB among farm workers represents a serious public health problem with previously unrecognized risk factors. Additional resources for migrant health care, improvements in health care access, and fundamental changes in the system of migrant labor are all necessary to reduce the transmission of TB.

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THE INCIDENCE of tuberculosis (TB) in the United States steadily declined until the mid-1980s, when cases associated with human immunodeficiency virus (HIV) infection interrupted this historical trend.^{1,2} In addition to HIV-infected persons, certain groups have a rate of TB far in excess of the general population, including minorities,^{3,4} the homeless,^{5,12} the incarcerated,

ed,¹³⁻¹⁷ alcoholics,¹⁸ and the poor.^{19,20} In eastern states, US-born farm workers most often originate from such groups. Farm workers also originate from Mexico, Central America, and Haiti, where annual case rates are three to 60 times

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that of the United States.²¹⁻²³ The retreat of TB into specific demographic groups is a key premise of the Strategic Plan for the Elimination of Tuberculosis in the United States.² Since the strategic plan cannot succeed as long as TB is endemic among migrant farm workers, an accurate understanding of the epidemiology of TB in this population is important.

Although only limited epidemiologic

data on TB among farm workers are available,²⁴ two recent studies^{25,26} found high levels of infection and active disease. Jacobson et al²⁵ reported a proportion of skin test reactivity (purified protein derivative [PPD] positivity) of 29% among US-born blacks and 55% among Haitians. However, sampling techniques employed in previous research precluded estimates of population parameters and risk factors were not studied. To accurately define the epidemiology of TB among migrants, a population-based study of a random sample of North Carolina migrant farm workers was conducted in 1988.

METHODS

The target population consisted of migrant farm workers and their families living in migrant camps in five North Carolina counties. Cluster sampling was employed, with camps as the sampling unit. Available lists of camps were merged, and a 10% random sample was obtained. Questionnaires (administered in the subject's preferred language) addressed risk factors and demographics. After informed consent, each subject received 5 TU of PPD (Connaught Laboratories, Willowdale, Ontario) in the volar surface of the left forearm^{27,28} and 0.05 mL (500 phosphorus nitrogen units per milliliter) of *Candida albicans* (Greer Laboratories, Lenoir, NC) in the right forearm (Mantoux method). Subjects with negative PPD and negative *Candida* tests received 0.05 mL of *Trichophyton* extract (Greer). Reactions were measured with calipers on two

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axes 48 hours after testing. Reactions of 10-mm induration or more on either axis were considered positive for all antigen tests.²⁷⁻³⁰ Subjects reporting prior severe local reactions or treatment for TB were not tested, but they provided sputum samples and answered questionnaires. Prior BCG vaccination in subjects was determined by questionnaire and visual inspection.

Sputum samples were induced from subjects with positive PPD tests with an ultrasonic nebulizer (Ultrasonic Nebulizer 65, Devilbiss, Somerset, Pa) and processed and examined within 48 hours by the Microbiology Branch of the North Carolina State Public Health Laboratory using standard methods.³¹ The PPD-positive subjects received chest roentgenograms at local county health departments where prophylaxis and treatment were prescribed. The TB case definition was based on the Public Health Service's recommendations for the reporting of TB, and a subject with one or more of the following indicators was considered a TB case: (1) a sputum sample positive for *Mycobacterium tuberculosis*; (2) roentgenographic findings consistent with pulmonary tubercular disease that led to therapy for active disease; and (3) current prescription of isoniazid and an additional antitubercular drug.^{32,33}

Data analysis used the χ^2 test, Fisher's Exact Test, *t* tests, logistic and linear regression, and Rtilogit (logistic regression adapted for cluster sampling³⁴). Three PPD variables were used in analysis. First, the *unadjusted PPD* was defined as the result of the PPD test. Second, the *adjusted PPD* excluded from the negative category of unadjusted PPD reactions those subjects with a negative *Candida* test and without a positive *Trichophyton* test (anergic subjects). Finally, *total PPD* contained, in addition to *adjusted PPD* values, subjects with reported prior positive PPD tests and confirmed negative PPD tests obtained at local clinics within 6 weeks of study participation. For linear regression, six dummy variables were created for gender, familial history of TB, residence in a migrant camp with a TB case, prior incarceration, homelessness, and homeless shelter residence. Two continuous independent variables were used: the log of years in farm work and of age. These eight variables constituted the full linear regression model. For the dependent continuous variable of PPD size, the sum of the two axis measurements was used. The logistic regression model used the same eight independent variables, with class of PPD reaction as the dependent variable.

Table 1.—Background Demographic and TB Variables of North Carolina Farm Workers in TB Study*

	Total (n = 543)	US-Born Blacks (n = 282)	Hispanics (n = 215)	Haitians (n = 34)
Demographic variables				
Mean age, y	34	36	26	40
Age >15 y, %	93	95	87	100
Males/females	5/1	6/1	6/1	3/1
Mean time in farm work, y	7.5	9.7	5.0	5.0
TB variables†				
TB in family, %	13	17	11	0
TB in migrant camp, %	32	52	6	3
BCG vaccination, %	45	‡	50	12
Previous PPD test, %	65	79	46	29
Prior positive PPD test, %	23	27	18	20
Prior diagnosis of TB, %	7	11	2	3
Prior medication for TB, %	11	17	5	3

*Number of subjects does not equal 543 because US-born whites and "other"

†TB indicates tuberculosis; PPD, purified protein derivative.

‡Information not requested of US-born blacks.

RESULTS

A total of 543 subjects in 31 migrant camps in five counties participated; 465 subjects were tested with PPD, 436 with *Candida*, and 28 with *Trichophyton*. Twenty-three percent of the 543 subjects reported a prior positive test for PPD. Fifteen reported negative tests within 6 weeks of study participation (Table 1). Subject number per camp ranged from three to 38 (mean, 17.8). Nonresponse was 5% or less among US-born blacks and Haitians and 15% to 20% among Hispanics.

Seventeen percent of US-born blacks reported a history of familial TB vs 9.6% of other subjects ($P < .05$; relative risk [RR], 2.0; 95% confidence interval [CI], 1.3 to 3.1), and 52% reported residence in a camp with a TB case vs 5.6% of other subjects ($P < .01$; RR, 18.1; 95% CI, 16.1 to 20.3, χ^2 tests) (Table 1). Of foreign-born subjects, 45% reported prior BCG vaccination (Table 1). Other risk factors were studied among white and US-born blacks only: 41% reported previous incarceration, 26% previously had resided in a homeless shelter, and 31% previously were homeless.

Eleven percent of all US-born blacks vs 2% of other subjects reported prior diagnosis of TB ($P < .01$; RR, 3.9; 95% CI, 1.5 to 9.8, χ^2 test); most subjects reported symptoms at diagnosis. Eleven percent of all subjects reported receiving TB medication, with US-born blacks (17%) reporting this far more often than other groups. Logistic regression was performed to test the association of variables with reported previous TB. Among US-born blacks only, years spent in migrant farm work ($P < .01$; odds ratio [OR], 1.06 per year; 95% CI, 1.03 to 1.22) and familial TB ($P < .01$; OR, 4.2; 95% CI, 3.5 to 5.1) had significant associations with prior TB (Rtilogit regression).

Results of PPD Testing

Of 465 subjects tested with PPD, 40.9% had a positive reaction (Table 2). 47% of anergic subjects ($n = 63$) were excluded (adjusted PPD), and 53% of subjects who reported positive PPD tests (total PPD) were included. Subjects reporting previous positive PPD tests appeared to be reliable because 46% of them had reported a prior TB diagnosis, 73% had received prior TB medication, 57% had resided in a migrant camp with a TB case, and 67% had a history of familial TB. Haitians had the highest PPD positivity (76%) and Hispanics the lowest. Forty-four percent of US-born blacks had a positive unadjusted PPD, 54% had a positive adjusted PPD, and 62% had a positive total PPD; 30% of Hispanics had a positive unadjusted PPD, 33% had a positive adjusted PPD, and 37% had a positive total PPD. Among those who were foreign born, BCG vaccination was not associated with positive PPD reactions (P is not significant [NS]; RR, 0.86; 95% CI, 0.74 to 1.0), even when previous positive PPD tests were included (NS; RR, 0.88; 95% CI, 0.75 to 1.0, χ^2 tests). Table 3 shows the RR of a positive PPD test associated with risk factors studied among US-born whites and blacks. For each variable, associations were significant when anergic subjects were excluded.

Regression Analysis of PPD Results

Regression analysis yielded significant values for US-born blacks only, and this analysis refers solely to this group. Years in farm work was the most important single variable. When log of years in farm work alone was tested against adjusted PPD, the R^2 value was .237 ($P = .0001$) vs .099 for log of age ($P = .0001$). The full model had an R^2 value of .22 ($P = .0001$) when anergic

subjects were included, but their exclusion increased the R^2 value to .32 ($P = .0001$). Using backward elimination, log of years in farm work, gender, TB in camp, and homelessness were selected (.06 level of significance was used since the values for several variables ranged from .051 to .054), with an R^2 value of .313 ($P = .0001$); years in farm work had by far the lowest P value (.0001). Results of logistic regression for US-born blacks (Table 4) were similar; years in farm work again had the lowest P value. With stepwise logistic regression (significance level, .05), years in farm work, TB in camp, and homelessness were selected, the same model selected by linear regression except that gender was eliminated.

Sputum Culture Results

Sputum samples were obtained from 172 PPD-positive subjects. One sample was obtained from 50 subjects, two from 96, and three from 24. Two Haitians and 16 US-born blacks were culture positive for mycobacteria other than tuberculosis, primarily the *Mycobacterium avium-intracellare-scofulaceum* or *M avium-intracellare* complex. The prevalence of mycobacteria other than tuberculosis among US-born blacks who provided sputum was 7%.

Active Tuberculosis

The prevalence of active TB among the entire sample was 2.0% and was confined to Hispanics (0.47%) and US-born blacks (3.6%). For two subjects, chest roentgenograms demonstrated active disease. One subject had sputum cultures that were positive for *M tuberculosis*. Eight subjects (seven US-born blacks and one Hispanic) were being treated for active disease at the time of the study (prescriptions were verified through health department records or inspection of prescriptions).

Among US-born blacks, years in farm work was associated with active TB ($P < .05$; RR, 2.6; 95% CI, 0.68 to 9.8, two-tailed Fisher's Exact Test, with mean years in farm work as the boundary of a dichotomous variable), while age (with mean age as a boundary) was not associated with active TB (NS, two-tailed Fisher's Exact Test). The RR for residence in a camp with a TB case was 5.4 ($P < .01$; 95% CI, 1.2 to 24.9), while familial TB was not significant (RR, 1.3; NS, two-tailed Fisher's Exact Test).

Anergy

Of subjects tested with *Candida*, 22% had negative reactions, 7.5% with positive PPD tests were *Candida* negative, and 14.5% were negative for both tests.

Table 2.—Results of PPD Testing: Percent Positive*

	Unadjusted PPD, % (n)†	Adjusted PPD, % (n)‡	Total PPD, % (n)§
Total	41 ± 5 (465)	47 ± 5 (402)	53 ± 5 (480)
US-born blacks	44 ± 6 (227)	54 ± 8 (185)	62 ± 6 (230)
US-born whites	38 ± 32 (8)	43 ± 37 (7)	50 ± 35 (8)
Haitians	76 ± 14 (34)	76 ± 14 (34)	76 ± 14 (34)
Hispanics	30 ± 7 (187)	33 ± 7 (168)	37 ± 7 (180)
US-born Hispanics	8 ± 9 (22)	8 ± 11 (19)	13 ± 13 (24)
Non-Haitian Caribbeans	55 ± 33 (9)	63 ± 33 (9)	67 ± 31 (9)

*PPD indicates purified protein derivative.

†Unadjusted PPD indicates percent who were PPD positive.

‡Adjusted PPD indicates percent who were PPD positive after excluding negative controls.

§Total PPD includes the values of reported PPD reactions in addition to adjusted PPD results.

¶Includes 95% confidence interval.

Table 3.—Relative Risk for PPD Positivity for Risk Factors Studied Among US-Born Blacks Only*

Risk Factors	Unadjusted PPD (n = 216)			Adjusted PPD (n = 176)		
	P	RR†	95% CI	P	RR	95% CI
Previous homelessness	.062	1.7	1.2-2.4	<.01	3.1	2.0-4.8
Previous residence in homeless shelter	.230	1.5	0.9-2.3	.01	2.6	1.6-4.2
Previous incarceration	.059	1.7	1.4-2.7	<.05	1.9	1.5-2.5

*PPD indicates purified protein derivative; RR, relative risk; and CI, confidence interval.

†According to χ^2 tests.

Table 4.—Logistic Regression: Main Effects Model Fit for US-Born Blacks*

Variable	P	OR	95% CI
Main Effects Model for Adjusted PPD†			
Age	NS	1.01/y	0.98-1.04
Years in farm work	<.001	1.11/y	1.06-1.17
Gender	NS	1.25 (Male)	0.41-3.82
Familial TB	<.05	3.8	1.05-13.95
Migrant camp TB	<.05	2.1	1.03-4.40
Homeless‡	NS	2.0	0.86-4.64
Incarceration	NS	1.7	0.79-3.56
Main Effects Model for Adjusted PPD: Stepwise Elimination§			
Years in farm work	<.001	1.11/y	1.06-1.17
Migrant camp TB	<.05	2.2	1.02-4.43
Homeless‡	<.05	2.6	1.22-5.67

*PPD indicates purified protein derivative; OR, odds ratio; CI, confidence interval; NS, not significant; and TB, tuberculosis.

†There were 167 observations (74 were PPD negative and 93 were PPD positive).

‡The two variables of prior homelessness and residence in a homeless shelter are combined in this variable.

§At .05 significance level.

Thus, a small number of PPD reactions may have been misclassified as false negatives. Measures of anergy were all higher among US-born blacks: 27% had negative *Candida* tests, 19% had negative reactions to both *Candida* and PPD, and 14% had a complete absence of reaction to *Candida*. No Haitians were both PPD and *Candida* negative. Only 4% of Hispanics had no reaction to *Candida*. Among US-born blacks, several risk factors for PPD positivity and prior diagnosis of TB were also associated with *Candida* negativity. Associations between negative *Candida* tests and residence in a homeless shelter, homelessness, and familial TB were all

significant at the .05 level, the RR for each exceeding 2.0 (χ^2 tests).

COMMENT

The use of random sampling in this study provides the most valid estimates of TB infection and risk in migrant farm workers. The prevalence of PPD positivity for the entire sample and for US-born blacks is the highest yet reported among farm workers. For each ethnic-national group of farm workers, PPD positivity was from 1.4 to 8.5 times that of the estimated national prevalence of 7.9%.²⁵ This study confirms previous reports²⁶⁻²⁸ that BCG vaccination may have no influence on PPD reaction. It is im-

portant that primary care providers be aware of this.

The number of cases of active TB among US-born blacks can be used as an approximation of the annual case rate among this group. This case rate (3.6%) is more than 3000 times the US case rate of roughly 10 per 100 000 persons⁴⁰ and seven times that found among Hispanics (0.47%) in this study. The Centers for Disease Control policy report, "Tuberculosis Among Migrant Farmworkers,"⁴¹ considers TB an imported problem in this population. Even on the basis of data available at the time of its publication (1985), this characterization is untenable because the data referenced in this document show that nearly all cases of TB occurred among US-born white and black farm workers, with none among Hispanics.²⁸

The results presented herein indicate that TB among farm workers is an occupational problem, not an imported one. All measures of TB risk and outcome among US-born blacks exceed those of other groups, with the single exception of PPD positivity among Haitians, but even the difference in PPD positivity (total PPD) between Haitians and US-born blacks was not statistically significant ($P = .08$). Moreover, the PPD positivity among US-born blacks in this sample exceeded that of Haitian farm workers reported in earlier studies.^{28,29} The organization of labor in migrant farm work explains these findings. Although foreign-born migrants originate from countries with high TB prevalence, the difficult migration to the United States is a selective process. Healthier individuals are more likely to reach the work force. However, US-born blacks commonly reported recruitment in homeless shelters, soup kitchens, and alcohol rehabilitation centers. For the US population in general, birth is usually protective, while birth in Latin America (where risk of primary infection may be 10 times that in the United States) is a primary risk factor.²⁸ Yet for farm workers, US birth is the risk factor, and birth in Latin America is protective. For the US population in general, al, age, gender, and history of familial TB are of primary importance as risk factors for TB.^{20,21,42-45} Among black American migrant farm workers, risk factors associated with farm work were far more important.

The association among US-born blacks between primary infection and years in farm work, rather than age, indicates that transmission of TB is common in farm work. Among US-born blacks, PPD positivity was four times that of close contacts of active cases, recently estimated at 15%.⁴⁶ County

health department records for one camp showed that of eight migrant workers tested in 1985, only two were PPD positive; all eight were positive when tested during this study. Eastern North Carolina has especially high rates of TB; among nonwhite men in the same age group as those in this study, the annual incidence of TB from 1984 to 1986 was 97.5 per 100 000 persons.⁴⁷ Since US-born black farm workers have more contact with local communities than those who are foreign born (and often exit and reenter the work force), TB among farm workers may contribute to the disproportionately high prevalence found in eastern North Carolina.

This is the first use of recall antigens in a population-based study of the epidemiology of TB, with possible implications for surveillance and control of TB, especially among high-risk groups. Only among US-born blacks did use of control antigens result in major changes in estimates of PPD positivity and increase the significance of risk factors, a trend observed with several modes of analysis. Without the use of recall antigens, the estimates of PPD positivity would be inaccurate due to false negatives, and the epidemiology of TB in the migrant population would be obscured. In addition, some risk factors were associated with both PPD positivity and recall antigen negativity. This suggests that the risk of contracting infection may also be associated with anergy, which would increase the risk of failure to detect infection with PPD testing. Thus, concurrent use of recall antigens with PPD testing may be useful in other situations, although some aspects of administration, such as size of positive reaction, need to be standardized. More studies are needed to determine the effectiveness of recall antigens in a clinical setting. Anergy may result from active TB^{48,49} and preexisting immunosuppression increases risk for disease, a phenomenon currently of great importance as a result of HIV-1 infection.^{44,45} The higher prevalence of anergy among US-born blacks is paralleled by the disproportionate prevalence of active TB in that group. A reservoir of undetected TB may exist among anergic individuals in this population, maintaining high rates of transmission. In addition, the prevalence of TB among US-born blacks may be influenced by HIV infection, the prevalence of which was estimated at over 4% in a clinic-based study in North Carolina.⁴⁸

The association between anergy and risk for TB is plausible. Homelessness and familial TB are associated with low socioeconomic status, still a critical factor in TB epidemiology.^{19,20} Alcoholism

(common among US-born black farm workers) may increase risk for TB¹⁹ as well as for anergy,^{48,49} malnutrition,⁴⁰ and probably other factors such as homelessness. In a recent study, Haitian farm workers were found to have the best nutritional levels and US-born blacks the worst⁵⁰; this corresponds to the levels of anergy found in these groups. For every nutrient studied, US-born blacks had intakes below the recommended daily allowance levels; of particular relevance with regard to cell-mediated immunity, inadequate levels of vitamin C, iron, and zinc were demonstrated.⁵¹

Tuberculosis among farm workers must be treated as an occupational problem. Risk for TB is institutionalized in migrant farm work in several ways, including a lack of access to health services. In an earlier study,²⁸ zero of 12 active cases had received medical attention. We found that the health of farm workers, even potential TB cases, was of the lowest priority for county health departments. Such attitudes must change before TB control can be achieved. The persistence of TB in this population, despite frequent treatment and prophylaxis, is not surprising. Historically, the decline in TB prevalence resulted from improved working and living conditions rather than chemotherapy.⁵² As long as farm work remains a system of exploitation and abuse, chemotherapy may repress but not greatly reduce prevalence.

The Strategic Plan for the Elimination of Tuberculosis in the United States, in which it is implicit that the persistence of TB in certain groups is unacceptable, should be a national health priority. However, this important and admirable goal will fail if TB is not eliminated from the population of migrant farm workers. In this population, as in other demographic groups with persisting high incidence of TB, it is probable that socioeconomic factors may prove considerable obstacles to the elimination of TB.

In order to improve surveillance and reduce the incidence of TB among migrant farm workers, the following recommendations are made:

1. The Strategic Plan for the Elimination of Tuberculosis in the United States contains numerous recommendations that should be adapted to and implemented among the population of farm workers, including the development and transfer of technology, such as gene probes for more rapid diagnosis, the use of advocacy groups for education, telephone reporting systems, and many others.

2. Regulation of TB services at the

state level often results in treatment delays. A central TB registry for farm workers, such as exists in Florida, would greatly facilitate provision of necessary services in other states.

3. Additional funding for migrant health care centers is needed. County health departments are also underfunded for TB services, but due to the linguistic, cultural, and logistical difficulties involved in migrant health care, designated migrant health care centers can most effectively provide services.

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