AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 51:195–203 (2008)

Green Tobacco Sickness and Skin Integrity Among Migrant Latino Farmworkers

Thomas A. Arcury, PhD,[1]* Quirina M. Vallejos, MPH,[1] Mark R. Schulz, PhD,[2] Steven R. Feldman, MD, PhD,[3] Alan B. Fleischer Jr., MD,[3] Amit Verma, MPH,[2] and Sara A. Quandt, PhD[4]

Background *Green tobacco sickness (GTS) affects approximately one-quarter of tobacco workers. The primary aim of this analysis is to expand existing knowledge of GTS risk factors by delineating the association of measures of skin integrity with the prevalence of GTS among Latino farmworkers.*

Methods *Data are from a longitudinal study of skin disease among 304 North Carolina Latino farmworkers conducted in 2005.*

Results *18.4% of the farmworkers met the GTS case definition. Self-reported rash increased the odds of having GTS in the bivariate (OR 2.29, 95% CI 1.21, 4.35), and multivariate analyses (OR 3.30, CI 2.17, 5.02). Self-reported itch (OR 3.54, CI 2.38, 5.24) and superficial wounds (OR 2.49, CI 1.15, 5.39) had a significant relationship to GTS in the bivariate analysis.*

Conclusions *These analyses extend current knowledge of GTS risk factors to include skin integrity. Farmworkers with rash and other skin conditions can protect these affected skin areas from exposure to the tobacco plant to reduce their risk of GTS.* Am. J. Ind. Med. 51:195–203, 2008. *© 2008 Wiley-Liss, Inc.*

KEY WORDS: agriculture; farming; farmworkers; Latino/Hispanic; health disparities

INTRODUCTION

Green tobacco sickness (GTS) is acute nicotine poisoning due to the transdermal absorption of nicotine [Quandt et al., 2001; Arcury et al., 2003]. Transdermal nicotine absorption occurs through contact with the green tobacco plant during planting, cultivating, harvesting and curing [Arcury and Quandt, 2006]. GTS has been described among farmers and farmworkers in different regions of the US, including Florida, North Carolina, Kentucky, Tennessee and Connecticut, as well as in Japan, India, and Italy [Weizenecker and Deal, 1970; Gehlbach et al., 1974; Ghosh et al., 1979; Misumi et al., 1983; Ballard et al., 1995; D'Alessandro et al., 2001; Arcury et al., 2001a,b, 2003; Trapé-Cardoso et al., 2003; Parikh et al., 2005]. While GTS is widely recognized, little research has examined its incidence, prevalence or risk factors. Arcury et al. [2001a,b] presented the first data on which incidence and prevalence for GTS can be based. In their study of Latino farmworkers in North

[1]Department of Family and Community Medicine, Wake Forest University School of Medicine, Winston-Salem, North Carolina
[2]Department of Public Health Education, University of North Carolina Greensboro, Greensboro, North Carolina
[3]Department of Dermatology, Wake Forest University School of Medicine, Winston-Salem, North Carolina
[4]Department of Epidemiology and Prevention, Division of Public Health Sciences, Wake Forest University School of Medicine, Winston-Salem, North Carolina
Contract grant sponsor: National Institute of Environmental Health Sciences; Contract grant number: R01-ES012358.
*Correspondence to: Thomas A. Arcury, Department of Family and Community Medicine, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157-1084. E-mail: tarcury@wfubmc.edu

Accepted 2 November 2007
DOI 10.1002/ajim.20553. Published online in Wiley InterScience (www.interscience.wiley.com)

Carolina, they found that the incidence density for GTS was 1.88 days for every 100 days of exposure, and that the prevalence for the agricultural season was 24.2%. Risk factors positively associated with GTS included task (topping, harvesting and barning tobacco) and working in wet clothing, while years of tobacco work experience was negatively associated with GTS. Tobacco consumption decreases the risk of GTS. As tobacco production continues to increase in poor communities around the world [Chacha, 2002; Arcury and Quandt, 2006], the number of small farmers and hired agricultural workers experiencing GTS will also increase. Knowledge of GTS risk factors is needed so that occupational safety training can reduce its prevalence.

Several other factors, including skin conditions [Quandt et al., 2000], have been hypothesized to contribute to the incidence of GTS, but these factors are difficult to measure and have not been included in analyses. Conditions that affect skin integrity, such as rashes, cuts and scrapes, may increase the risk of GTS by facilitating nicotine absorption. Transdermal nicotine absorption may increase with skin damage or disease to levels that are far higher than levels found with intact skin [Wester and Maibach, 1983; Benowitz et al., 1987].

Farmworkers are a medically underserved population with significant rates of injury and illness, and limited access to health services [Villarejo, 2003; Arcury and Quandt, 2007]. Farmworkers in the US are overwhelmingly Latino, with the majority being from Mexico [Carroll et al., 2005]. Farmworkers experience significant rates of skin conditions [McCurdy et al., 1989; Gamsky et al., 1992; Villarejo and Baron, 1999; Krejci-Manwaring et al., 2006], including dermatitis and superficial wounds. They often defer medical care for skin conditions and self-treat [Arcury et al., 2006]. Determining the association of conditions that alter skin integrity with GTS may provide another point of intervention to reduce this occupational illness among farmworkers.

The primary aim of this analysis is to delineate the association of skin conditions with the prevalence of GTS among Latino farmworkers. This analysis will also describe prevalence of GTS among Latino farmworkers across an agricultural season and present associations of GTS with personal and work characteristics.

MATERIALS AND METHODS

Data are from a longitudinal surveillance study of skin disease prevalence and risk factors among migrant farmworkers in eastern North Carolina. Data collection included baseline and up to four follow-up assessments at approximately 3-week intervals. Data were collected from May through October 2005. The study methods have been described in detail elsewhere [Taylor et al., 2006; Arcury et al., 2007; Quandt et al., in press], and are summarized here.

Sample

The sample was selected from among farmworkers employed in a nine county area of eastern North Carolina that includes Edgecombe, Greene, Harnett, Johnston, Lenoir, Sampson, Nash, Pitt, and Wilson counties. Farmworkers constitute a ''hard-to-reach'' population for which no sampling frame exists (Magnani et al., 2005). Therefore, the sample was selected in two stages to reduce the likelihood of selection bias. First, 45 farmworker camps in these nine counties were randomly selected from lists provided by two migrant clinics and one farmworker service agency serving these counties. Second, up to seven farmworkers residing in each camp were recruited from a census list of each site (sites often had fewer than seven residents). Initially, 242 farmworkers were recruited, with individual participants replaced at the first through third follow-up interviews if other site residents indicated that the workers had permanently left the area. The final sample included 304 farmworkers (300 Latino men, 4 Latina women) from the 45 camps. A total of 1,048 contacts or data points occurred among the 304 participants. Loss to follow-up across the data collection period is consistent with other longitudinal research with migrant farmworker populations [Quandt et al., 2002].

Data Collection

Data collection included an interviewer-administered questionnaire and a standard set of ten digital photographs. The questionnaire was developed in English, translated into Spanish by a professional translator familiar with Mexican Spanish, reviewed by three other native Mexican Spanish speakers familiar with farmworkers, and pretested with five Latino farmworkers. Based on the review and pretest, questionnaire wording was modified. The interview questionnaire included items addressing demographic and background information, as well as current work and living conditions. Participants were asked to report the presence of a set of 19 skin problems experienced in the previous week, as well as other symptoms experienced in the previous week that included nausea, vomiting, dizziness, and headache. The ten digital photographs taken of each participant included one view of the face with the participant holding an ID number, one frontal view of the face, two profiles of the face, frontal and dorsal views of the torso and arms, palmar and dorsal surfaces of the hands, and plantar and dorsal surfaces of the feet. Photos were taken with an image size of $2{,}592 \times 1{,}944$ pixels and a FINE image quality setting (compression to one-quarter size of original). Images were stored as JPEG files on a secure HIPAA-compliant server housed at Wake Forest University Baptist Medical Center. Participants received a cash incentive of $10 at each interview and a hat with an occupational health message at their initial interview. Data collection procedures were

reviewed and approved by the Wake Forest University School of Medicine Institutional Review Board. All participants provided signed informed consent.

Measures

The outcome variable for this analysis is GTS. Our case definition for GTS is based on that used in earlier analyses [Arcury et al., 2001a,b, 2003; Quandt et al., 2001]: reporting dizziness or headache, and nausea or vomiting, and working in tobacco in the 7 days period before the interview. Symptoms were self-reported as having occurred in the 7 days prior to the interview, and working in tobacco was reported for each of the 7 days prior to the interview. In no instance did an individual report dizziness or headache, plus nausea or vomiting in the previous 7 days, and not report having worked in tobacco during that period.

Skin conditions are the major predictor of interest for this analysis. Two sets of skin conditions are considered. The self-reported skin problems of itching, rash and superficial wounds are based on participants indicating whether or not they had each problem in the interviews [Vallejos et al., in press]. The diagnosed skin problems of contact dermatitis and traumatic skin lesions are two of 17 specific skin disease diagnoses made by a single board-certified dermatologist (SRF) based on his review of each set of nine standardized digital images recorded at the time each participant was interviewed [Arcury et al., 2007]. These are all dichotomous (present/absent) measures.

Other variables included in the analysis have been shown to have an association with GTS and need to be considered to examine the association of skin conditions with GTS [Arcury et al., 2001a,b]. Personal characteristics were age (18–24 years, 25–30 years, 31–40 years, 41 years and older); and years in US agriculture (1 year or less, 2–3 years, 4–7 years, 8 or more years). Work activities for the previous 7 days included the dichotomous measures planted, harvested, cultivated, topped tobacco (removing the flowers from the plant), and barned or baled tobacco. Work conditions included the dichotomous measures of worked in wet shoes or clothes, and wore a rain suit on any of the previous 7 days. The growing season was divided into six periods of approximately 3 weeks duration. These periods correspond to different stages in tobacco production: from May 29, to June 19, tobacco has been set and requires little direct contact; from June 20, to July 10, tobacco is being topped and early tobacco is being and put into the barn to cure; from July 11, to July 31, topping tobacco is completed, and tobacco harvesting and curing continue; from August 1, to August 21, and from August 22, to September 10, the primary activities are harvesting and curing tobacco; from September 11, to October 12, tobacco harvesting is largely completed. Due to the longitudinal design of this study in which participants were contacted at 3-week intervals, the structure of these periods ensures that no participant appears more than one time in each period.

Analysis

Prevalence of GTS, self-reported skin problems, diagnosed skin problems, personal characteristics, and work activities and conditions were described with counts and frequencies for the season as a whole and for each time period. The dichotomous outcome for GTS was modeled as a function of independent variables for specific skin problems, personal characteristics, and work activities and conditions with logistic regression. For the GTS outcome variable, an initial model was constructed that included the covariates reported in Tables I and II. The harvested crops variable was subdivided into three crop-specific harvest variables: 'harvested crops other than tobacco', 'harvested tobacco and other crops' and 'harvested tobacco only'. The latter two variables were placed in the model instead of the general harvested crops variable.

The initial model was reduced to a final model by focusing on the odds ratios (OR) estimated for three work characteristics previously shown to be strong predictors of GTS (harvested tobacco only, barned or bailed tobacco, and topped tobacco) and then eliminating one by one covariates whose subtraction from the model did not change the OR between any of these three predictors and the outcome by more than 20%. The goal was to identify the simplest final model of skin conditions and previously identified work characteristics associated with GTS; thus, at each step all skin conditions were retained for which the OR and corresponding 95% confidence intervals did not include 1.0. In all preliminary models any category of seasons in US agriculture greater than one was protective against GTS, but the protection did not increase monotonically with seasons worked. Therefore, seasons in US agriculture was included as a dichotomous variable (one vs. two or more seasons) in the final model. The regression coefficients (and their standard errors) in the multivariate logistic model were determined with the alternating logistic regression estimation procedure [Cary et al., 1993] to account for the typically correlated multiple observations from the same farmworker, as well as possibly correlated multiple observations from farmworkers employed at the same camp. Multivariate adjusted prevalence OR and their 95% confidence intervals (CI) were determined by exponentiation of the log OR from the multivariate logistic regression. The magnitude of the clustering of outcome within farmworkers and between farmworkers within camps was estimated with pairwise OR [Preisser et al., 2003]. The descriptive analysis used SPSS version 14.0 (SPSS Inc., Chicago, IL), and the alternating logistic regressions used SAS version 9.1 (SAS Institute Inc., Cary, NC).

TABLE I. Work Activities and Conditions of Farmworkers, Eastern North Carolina, 2005

Work activities and conditions	Period 1, May 29 to June 19 (N = 141)		Period 2, June 20 to July 10 (N = 187)		Period 3, July 11 to July 31 (N = 226)		Period 4, August 01 to August 21 (N = 199)		Period 5, August 22 to September 10 (N = 187)		Period 6, September 11 to October 12 (N = 95)	
	n	%	n	%	n	%	n	%	n	%	n	%
Work activity in the previous 7 days[a]												
Planted	37	26.2	30	16.0	12	5.3	6	3.0	0	0.0	0	0.0
Cultivated	39	27.7	16	8.6	5	2.2	3	1.5	0	0.0	0	0.0
Topped tobacco	6	4.3	105	56.1	147	65.0	45	22.6	6	3.2	0	0.0
Harvested—tobacco only	4	2.8	5	2.7	47	20.8	75	37.7	63	33.7	33	34.7
Harvested—tobacco and other	7	5.0	13	7.0	16	7.1	8	4.0	8	4.3	5	5.3
Harvest—no tobacco	48	34.0	38	20.3	11	4.9	9	4.5	8	4.3	18	18.9
Barned or baled tobacco	0	0.0	0	0.0	32	14.2	78	39.2	118	63.1	39	41.1
Work conditions in the previous 7 days												
Worked in wet shoes or clothes	46	32.6	72	38.5	133	58.8	119	59.8	98	52.4	45	47.4
Wore rain suit	6	4.3	14	7.5	36	15.9	37	18.6	38	20.3	17	17.9

[a]Adds to greater than 100% as workers may participate in more than one work activity in a 7-day period.

RESULTS

The 304 farmworkers who participated in this study were predominately young adults, with 26.0% aged 18–24 years, 22.7% aged 25–30 years, 34.2% aged 31–40 years, and 17.1% aged 41 years or older. Almost one-quarter (22.7%) worked in US agriculture for 1 year or less, with 27.1% having worked in US agriculture for 2–3 years, 25.4% for 4–7 years, and 24.8% for 8 years or more. Work activities among the participating farmworkers varied across the season, with planting, cultivating, and harvesting tobacco being dominant activities in the early part of the season, topping tobacco being dominant in the middle of the season, and harvesting tobacco and barning and baling tobacco being dominant in the later part of the season (Table I). Working in wet shoes and clothes was common throughout the season. Wearing a rain suit was greatest (at about 20%) during the latter half of the season.

Almost one in five (18.4%) of the farmworkers participating in this study had the combination of attributes that indicated they had GTS at least one time during the agricultural season (Table II). The percent of farmworkers with GTS varied across the season with 2.1% and 2.7% experiencing GTS in the first third of the season (Periods 1 and 2, May 29 through July 10), when there is little tobacco work except for topping tobacco during the latter part of this portion of the season. The percent of farmworkers with GTS increased to 8.0% in the latter half of July, to 11.6% in August and to 10.2% in late August and early September. During July through September tobacco is topped, picked, and put in the barn. In the September to October period, 2.1% had GTS. Tobacco production is generally completed in early September in eastern North Carolina.

Almost one-third of the farmworkers experienced nausea (22.0%) or vomiting (9.9%) at some time during the season. Over half (54.3%) of the farmworkers experienced headache, and 27.0% experienced dizziness at some time during the season. The greatest percentage of farmworkers who experienced nausea or vomiting and headache or dizziness was in the middle of the season, from July 11 through September 10.

Almost half (46.1%) of participants self-reported itching at some time during the agricultural season, 42.8% reported a rash, and 27.3% reported a superficial wound. Participants who reported itching and rash were comparable for each period, and analysis (not reported) showed that these two skin problems were highly correlated. The percentage of participants who reported itching and rash was greatest in July (28.3% and 24.8%, respectively) and August (21.1% and 22.1%). The percentage of participants who reported a superficial wound was greatest in May (17.7%), and remained near 10% for the remainder of the season.

Contact dermatitis was diagnosed for 12.2% of participants at least once during the agricultural season,

TABLE II. Green Tobacco Sickness, Symptoms, and Skin Conditions Among Farmworkers, Eastern North Carolina, 2005

Green tobacco sickness, symptoms and skin problems	Total (N = 304)		Period 1, May 29 to June 19 (N = 141)		Period 2, June 20 to July 10 (N = 187)		Period 3, July 11 to July 31 (N = 226)		Period 4, August 01 to August 21 (N = 199)		Period 5, August 22 to September 22 (N = 187)		Period 6, September 11 to October 12 (N = 95)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Green tobacco sickness	56	18.4	3	2.1	5	2.7	18	8.0	23	11.6	19	10.2	2	2.1
Symptoms in previous 7 days														
Nausea	67	22.0	7	5.0	12	6.4	19	8.4	28	14.1	18	9.6	2	2.1
Vomiting	30	9.9	0	0.0	2	1.1	12	5.3	15	7.5	9	4.8	2	2.1
Headache[a]	165	54.3	26	18.4	40	21.4	66	29.2	68	34.2	52	27.8	13	13.7
Dizziness	82	27.0	5	3.5	9	4.8	22	9.7	32	16.1	30	16.0	6	6.3
Skin problems														
Self-report itching in previous 7 days	140	46.1	29	20.6	25	13.4	64	28.3	42	21.1	33	17.6	11	11.6
Self-report rash in previous 7 days	130	42.8	26	18.4	27	14.4	56	24.8	44	22.1	37	19.8	10	10.5
Self-reported superficial wounds in previous 7 days	83	27.3	25	17.7	15	8.0	23	10.2	16	8.0	17	9.1	6	6.3
Diagnosed contact dermatitis	37	12.2	3	2.1	7	3.7	8	3.5	6	3.0	10	5.3	5	5.3
Diagnosed traumatic skin lesion	51	16.8	10	7.1	11	5.9	6	2.7	12	6.0	12	6.4	7	7.4

[a]Headache data were missing for two farmworkers in period 3, one farmworker in period 4, and one farmworker in period 5.

while traumatic skin lesions were diagnosed for 16.8% of participants. Contact dermatitis was diagnosed for 5.3% or fewer participants for each period, while traumatic skin lesions were diagnosed for 6–7% of participants for all but period 3, when the percent was 2.7%.

Bivariate analyses indicated that each of the self-reported skin problems was related to having GTS, while the two diagnosed skin problems were not (Table III). Self-reported itching increased the odds of GTS by 2.29 (95% CI 1.21, 4.35), and self-reported rash increased the odds by 3.54 (95% CI 2.38, 5.24). Self-reported superficial wounds increased the odds of GTS by 2.49 (95% CI 1.15, 5.39). The personal characteristics age and seasons in agriculture did not affect the odds of GTS. The work activities of harvesting tobacco only (OR 1.84 95% CI 1.00, 3.39) and barning or baling tobacco (OR 2.06 95% CI 1.14, 3.71) were related to having GTS. Finally, working in wet shoes or clothes increased the odds of having GTS (OR 1.81 95% CI 1.08, 3.03).

Self-reported rash significantly increased the odds of GTS in the multivariate analysis (Table IV) (OR 3.30, 95% CI 2.17, 5.02). Working 2 or more years in US agriculture greatly reduced odds of GTS (OR .37, 95% CI 0.15, 0.93). The work activities topping tobacco (OR 4.13 95% CI 2.16, 7.88), harvesting only tobacco (OR 4.61, 95% CI 2.25, 9.46), and barning and baling tobacco (OR 6.25, 95% CI 3.25, 12.02) all increased the odds of GTS. Wearing a rain suit decreased the odds of GTS (OR 0.21, 95% CI 0.05, 0.85). The Alpha 1 within person OR of 4.77 (95% CI 1.43, 15.90) indicated that GTS clustered for some individual

TABLE III. Bivariate Analysis of the Association of Skin Conditions, Personal Characteristics and Work Activities and Conditions With Green Tobacco Sickness Among Farmworkers, Eastern North Carolina, 2005

Skin conditions, personal characteristics, and work activities and conditions	Green tobacco sickness	
	Odds ratio	95% CI
Skin problems		
Self-report itching in previous 7 days	2.29	1.21, 4.35
Self-report rash in previous 7 days	3.54	2.38, 5.24
Self-reported superficial wounds in previous 7 days	2.49	1.15, 5.39
Diagnosed contact dermatitis	2.13	0.73, 6.22
Diagnosed traumatic skin lesions	0.77	0.43, 1.37
Personal characteristics		
Age		
18–24 years (reference)	—	—
25–30 years	1.08	0.48, 2.47
31–40 years	0.86	0.43, 1.72
41 years and older	0.62	0.25, 1.53
Seasons in US agriculture		
1 year or less (reference)	—	—
2–3 years	0.62	0.19, 2.07
4–7 years	0.38	0.14, 1.06
8 or more years	0.56	0.20, 1.58
Work activities and conditions in previous 7 days		
Planted	0.49	0.15, 1.58
Cultivated	0.44	0.12, 1.66
Topped tobacco	1.54	0.85, 2.80
Harvested—tobacco only	1.84	1.00, 3.39
Harvested—tobacco and other	1.67	0.69, 4.03
Harvested—no tobacco[a]	0.00	undefined
Barned or baled tobacco	2.06	1.14, 3.71
Worked in wet shoes or clothes	1.81	1.08, 3.03
Wore rain suit	0.55	0.15, 1.99

[a]Among the 70 farmworker observations where Green tobacco sickness was evident there was not a single observation in which the farmworker had harvested only a crop other than tobacco in the preceding 7 days.

TABLE IV. Multivariate Analysis of the Association of Skin Conditions, Personal Characteristics, and Work Activities and Conditions With Green Tobacco Sickness Among Farmworkers, Eastern North Carolina, 2005

Skin conditions, personal characteristics, and work activities and conditions	Green tobacco sickness (GTS)	
	Odds ratio	95% CI
Skin problems		
Self-reported rash	3.30	2.17, 5.02
Personal characteristics		
$\geq$ 2 seasons in US agriculture	0.37	0.15, 0.93
Work activities and conditions		
Topping tobacco	4.12	2.16, 7.88
Harvesting only tobacco	4.61	2.25, 9.46
Barning and baling tobacco	6.25	3.25, 12.02
Wore rain suit	0.21	0.05, 0.85
Alpha 1 within person	4.77	1.43, 15.90
Alpha 2 within camp	1.25	0.92, 1.72

participants—specific participants had GTS on more than one occasion. The Alpha 2 within camp OR indicated that GTS cases did not cluster within camps.

DISCUSSION

GTS remains a common occupational illness among farmworkers who cultivate and harvest tobacco. The overall prevalence for the approximately 4 month growing season among farmworkers who participated in this study, 18.4%, is similar to earlier reports [Arcury et al., 2001a,b]. Determining the association of skin conditions with the occurrence of GTS was the primary aim of this analysis [Quandt et al., 2000]. Self-reported rash increased the odds of having GTS in the bivariate and multivariate analyses. Other measures of self-reported skin problems, including itch and superficial wounds, had a significant relationship to GTS in the bivariate analysis. Itch was not included in the multivariate analysis because it was highly correlated with rash. The diagnosed skin problems contact dermatitis and traumatic skin lesions did not have a significant relationship with GTS in the bivariate or multivariate analyses. Skin conditions do increase the odds of GTS. However, these skin problems must have sufficient intensity to draw the attention of the farmworkers. Rash, which compromises the skin surface and increases the potential absorption of nicotine, is the skin problem most strongly related to GTS.

In addition to rash, several other factors were found to be related to the occurrence of GTS. These risk factors have been identified in earlier analyses [Arcury et al., 2001a,b]. Work activities that place the individual in greatest contact with tobacco, topping, harvesting and barning, all increase the odds of having GTS. Work experience, having worked 2 or more years in tobacco production, reduces the risk of GTS. Several factors may account for low occurrence of GTS with greater experience. It may result from self-selection: those who experience GTS may avoid farm work. Individual workers may learn how to minimize contact with tobacco plants that results in nicotine absorption.

Pesticides, particularly organophosphorous insecticides, cannot be completely ruled out as causal factors for some of the symptoms that form the GTS case definition. Organophosphorous insecticides, such as acephate, are applied to tobacco, and exposure to these organophosphorous insecticides can cause nausea, vomiting, headache, and dizziness. However, insecticides would rarely be applied to tobacco near the time of harvest. Further, exposure to organophosphorous insecticides that was sufficiently severe to cause nausea, vomiting, headache, or dizziness would likely cause other symptoms (e.g., excessive salivation and lacrimation, pinpoint pupils, muscle ache) that workers are likely to report. Symptoms such as nausea, vomiting, headache or dizziness that result from organophosphorous insecticide exposure could also occur when farmworkers cultivate or harvest other crops to which organophosphorous insecticides are applied, such as tomatoes and bell peppers. However, the two components of the case definition, dizziness or headache and nausea or vomiting, only occurred together when the participant worked in tobacco.

Wearing a rain suit has been suggested as a procedure to reduce the occurrence of GTS [Gehlbach et al., 1979; Arcury et al., 2002]. Nicotine is both water and lipid soluble. Even individuals wearing long-sleeved shirts and long pants can be exposed to nicotine when water on tobacco plants, which contains nicotine [Gehlbach et al., 1975], saturates clothing. Wearing a rain suit while harvesting tobacco that is wet from

dew or rain will reduce contact with the nicotine in this water and help prevent GTS. This is the first epidemiological study to document this relationship.

Another intervention to reduce GTS, in addition to wearing a rain suit, suggested by these results is that workers with skin conditions, particularly rash, should be advised to take extra caution and protect these areas from exposure to green tobacco. Farmworkers should wear clothing to protect against skin conditions, and that protect areas of damaged skin. They should also change out of wet clothing as soon as possible to reduce the risk of skin damage and to reduce exposure to nicotine. This could include taking a change of dry clothes to the fields each morning. Farmworkers with skin conditions should be taught to use moisturizers to treat dried and cracked skin. With the high percentage of new farmworkers each year and the greater risk of GTS among new farmworkers, veteran farmworkers could be trained to teach new workers about skin protection and protection from wet tobacco. This information could also be provided by clinic outreach staff.

This study has several limitations and strengths that should be considered. Measuring GTS was not the primary goal of the study from which these data were drawn. This analysis lacks a direct measure of GTS, or a biomarker of GTS. We also did not include a measure of smoking; tobacco consumption can reduce the occurrence of GTS. While the measure of GTS is not direct, it should be noted that the combined symptoms of nausea or vomiting and headache or dizziness occurred only among those who had worked in tobacco. This measure has been used in previous studies, and it is correlated to cotinine levels [Quandt et al., 2001; Arcury et al., 2003]. The measures of skin conditions included self-reported problems as well as diagnosed diseases. The analysis is based on a large sample of farmworkers. Participants provided data for repeated measures of GTS and skin conditions, and appropriate analytic methods were used for the repeated measures design.

This analysis indicates that GTS continues to be a common occupational illness among farmworkers who cultivate and harvest tobacco. It is the first analysis to provide epidemiologic data on the association of skin conditions with the occurrence of GTS. These results indicate that modifiable factors can reduce GTS among farmworkers. In addition to wearing a rain suit while working in wet tobacco, farmworkers with rash and other skin conditions can protect these affected skin areas from exposure to the tobacco plant.

REFERENCES

Arcury TA, Quandt SA. 2006. Health and social impacts of tobacco production. J Agromedicine 11:71–81.

Arcury TA, Quandt SA. 2007. Delivery of health services to migrant and seasonal farmworkers. Annu Rev Public Health 28:345–363.

Arcury TA, Quandt SA, Preisser JS, Norton D. 2001a. The incidence of green tobacco sickness among Latino farmworkers. J Occup Environ Med 43:601–609.

Arcury TA, Quandt SA, Preisser JS. 2001b. Predictors of incidence and prevalence of green tobacco sickness among Latino farmworkers in North Carolina, U.S.A. J Epidemiol Community Health 55:818–824.

Arcury TA, Quandt SA, Garcia DI, Preisser JS, Norton D, Rao P. 2002. A clinic based case–control comparison of green tobacco sickness among minority farmworkers. South Med J 95:1008–1011.

Arcury TA, Quandt SA, Preisser JS, Bernert JT, Norton D, Wang J. 2003. High levels of transdermal nicotine exposure produce green tobacco sickness in Latino farmworkers. Nicotine Tob Res 5:315–321.

Arcury TA, Vallejos QM, Feldman SR, Quandt SA. 2006. Treating skin disease: Self-management behaviors of Latino farmworkers. J Agromedicine 11:27–35.

Arcury TA, Feldman SR, Schulz MR, Vallejos QM, Verma A, Fleischer AB, Rapp SR, Davis SF, Preisser JS, Quandt SA. 2007. Diagnosed skin diseases among migrant farmworkers in North Carolina: Prevalence and risk factors. J Agric Saf Health 13:407–418.

Ballard T, Ehlers J, Freund E, Auslander M, Brandt V, Halperin W. 1995. Green tobacco sickness: Occupational nicotine poisoning in tobacco workers. Arch Environ Health 50:384–389.

Benowitz NL, Lake T, Keller KH, Lee BL. 1987. Prolonged absorption with development of tolerance to toxic effects after cutaneous exposure to nicotine. Clin Pharmacol Ther 42:119–120.

Carroll DJ, Samardick R, Bernard S, Gabbard S, Hernandez T. 2005. Findings from the National Agricultural Workers Survey (NAWS) 2001–2002: A Demographic and Employment Profile of United States Farm Workers. Research Rep. 9, Washington, DC: US Department of Labor, Office of the Assistant Secretary for Policy.

Cary VJ, Zeger SL, Diggle P. 1993. Modeling multivariate binary data with alternating logistic regressions. Biometrika 80:517–526.

Chacha BK. 2002. From pastoralists to tobacco peasants: The British American Tobacco (B.A.T.) and socio-ecological change in Kuria District, Kenya, 1969–1999. In Killing Trees to Cure Forests: Ethnicity, Economy, and Environment. Conference Proceedings. Nairobi, Kenya: Great Lakes Colleges Association, University of Nairobi.

D'Alessandro A, Benowitz NL, Muzi G, Eisner MD, Filiberto S, Fantozz P, Montanari L, Abbritti G. 2001. Systemic nicotine exposure in tobacco harvesters. Arch Environ Health 56:257–263.

Gamsky TE, McCurdy SA, Wiggins P, Samuels SJ, Berman B, Shenker MB. 1992. Epidemiology of dermatitis among California farm workers. J Occup Med 34(3):304–310.

Gehlbach SH, Williams WA, Perry LD, Woodall JS. 1974. Green-tobacco sickness: An illness of tobacco harvesters. JAMA 229:1880–1883.

Gehlbach SH, Williams WA, Perry LD, Freedman JI, Langone JJ, Peta LV, Woodall JS. 1975. Nicotine absorption by workers harvesting green tobacco. Lancet 305(7905):478–480.

Gehlbach SH, Williams WA, Freedman JI. 1979. Protective clothing as a means of reducing nicotine absorption in tobacco harvesters. Arch Environ Health 34:111–114.

Ghosh SK, Parikh JR, Gokani VN, Kashyap SK, Chatterjee SK. 1979. Studies on occupational health problems during agricultural operation of Indian tobacco workers. J Occup Med 21:45–47.

Krejci-Manwaring J, Schulz MR, Feldman SR, Vallejos Q, Quandt SA, Rapp SR, Arcury TA. 2006. Skin disease among Latino farmworkers in North Carolina. J Agric Saf Health 12:155–163.

Magnani R, Sabin K, Saidel T, Heckathorn D. 2005. Review of sampling hard-to-reach and hidden populations for HIV surveillance. AIDS 19 (suppl 2):S67–S72.

McCurdy SA, Wiggins P, Schenker MB, Munn J, Shaieb AM, Weinbaum C, Goldim D, McGillis ST, Berman B, Samuels S. 1989. Assessing dermatitis in epidemiologic studies: Occupational skin disease among California grape and tomato harvesters. Am J Ind Med 16:147–157.

Misumi J, Koyama W, Miura H. 1983. Two cases of ''green tobacco sickness'' in the tobacco harvesters and the absorption of nicotine through the skin in the rat. Sangyō Igaku 25(1):3–9.

Parikh JR, Gokani VN, Doctor PB, Kulkarni PK, Shah AR, Saiyed HN. 2005. Acute and chronic health effects due to green tobacco exposure in agricultural workers. Am J Ind Med 47:494–499.

Preisser JS, Arcury TA, Quandt SA. 2003. The spatial clustering of an occupational illness: Green tobacco sickness among Latino farmworkers. Am J Epidemiol 158:495–501.

Quandt SA, Arcury TA, Preisser JS, Norton D, Austin CK. 2000. Migrant farmworkers and green tobacco sickness: New issues for an understudied disease. Am J Ind Med 37:307–315.

Quandt SA, Arcury TA, Preisser JS, Bernert JT, Norton D. 2001. Behavioral and environmental predictors of salivary cotinine in Latino tobacco workers. J Occup Environ Med 40:844–852.

Quandt SA, Preisser JS, Arcury TA. 2002. Mobility patterns of migrant farmworkers in North Carolina: Implications for occupational health research and policy. Hum Organ 61:21–29.

Quandt SA, Schulz MR, Vallejos QM, Feldman JS, Arcury TA. (in press). Skin-related quality of life among migrant farmworkers. J Cutan Med Surg.

Taylor SL, Coates ML, Vallejos Q, Feldman SR, Schulz MR, Quandt SA, Fleischer AB, Arcury TA. 2006. Pterygium among Latino migrant farmworkers in North Carolina. Arch Environ Occup Health 61:27–32.

Trapé-Cardoso M, Bracker A, Grey M, Kaliszewski M, Oncken C, Ohannessian C, Barrera LV, Gould B. 2003. Shade tobacco and green tobacco sickness in Connecticut. J Occup Environ Med 45:656–661.

Vallejos QM, Schulz MR, Quandt SA, Feldman SR, Galvan L, Verma A, Fleischer AB, Rapp SR, Arcury TA. (in press). Self report of skin problems among farmworkers in North Carolina. Am J Ind Med.

Villarejo D. 2003. The health of U.S. hired farm workers. Annu Rev Public Health 24:175–193.

Villarejo D, Baron SL. 1999. The occupational health status of hired farm workers. Occup Med 14:613–635.

Weizenecker R, Deal WB. 1970. Tobacco cropper's sickness. J Fla Med Assoc 57(12):13–14.

Wester RC, Maibach HI. 1983. Cutaneous pharmacokinetics: 10 steps to percutaneious absorption. Drug Metab Rev 14:169–206.