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The Incidence of Green Tobacco Sickness Among Latino Farmworkers

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We estimated the prevalence and incidence density (ID) and the risk factors of green tobacco sickness among minority **farmworkers** in North Carolina. Using a prospective surveillance design, 182 **farmworkers** were interviewed up to 5 times at biweekly intervals in 1999. The green tobacco sickness prevalence was 24.2%, whereas the ID was 1.88 days per 100 days worked. Greater work experience (5+ years, ID = 0.87; first year ID = 2.41) and tobacco use (ID of 1.18 vs 2.39) were negatively associated with green tobacco sickness. Task (eg, priming ID, 4.04; topping ID, 1.86; barning ID, 0.62) and working in wet clothing (25% of workdays ID, 2.97; fewer than 25% of workdays ID, 1.29) had the largest effect. More effort must be directed toward preventing this occupational illness that affects workers who have little control over workplace safety.

Introduction

Green tobacco sickness (GTS) is an occupational illness that affects agricultural workers involved in the cultivation and harvesting of tobacco. Today, most hand cultivation and harvesting in the United States are being done by Latino migrant and seasonal **farmworkers**. In other tobacco-producing regions of the world, those who cultivate and harvest tobacco also have limited power and economic resources. It is vitally important for occupational and environmental health and justice research to delineate the health burden of tobacco cultivation. In this article, we report the results from the first prospective surveillance study of GTS among migrant and seasonal **farmworkers**. We report the general prevalence and incidence of GTS among **farmworkers** in eastern North Carolina, delineate changes in GTS incidence over the course of a production season, and identify the risk factors associated with the incidence of GTS among these workers.

GTS Symptoms

GTS is caused by acute nicotine poisoning that results from the transdermal absorption of nicotine through contact with the green tobacco plant. [1] [2] GTS is well-known among agricultural workers in tobacco-growing regions, [3] but fewer than 40 articles on GTS can be found in the occupational health and medical literature. [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] It was first described in 1970 among tobacco workers in Florida. [14] Since then, the cause has been attributed to acute nicotine poisoning following dermal contact with mature tobacco plants, *Nicotiana tabacum*. [2] No diagnostic criteria have been established for GTS. The symptoms of GTS are dizziness or headache and nausea or vomiting occurring in the afternoon or evening,

but they may also include abdominal cramps, headache, prostration, difficulty breathing, abdominal pain, diarrhea, and (occasionally) fluctuations in blood pressure or heart rate. [1] [2] [3] [4] [5] [7] [9] [10] [11] [12] [15] [16] [17] GTS is normally self-limiting, [1] [2] but symptoms may be severe enough to result in dehydration and the need for emergency medical care.

Quandt et al summarized the biology and pharmacokinetics of GTS. [18] Nicotine is an alkaloid compound that is readily absorbed through the skin. [19] The skin acts both as a barrier and as the primary route into systemic circulation for chemicals. The surfaces of wet tobacco leaves contain nicotine, which is easily absorbed. [20] [21] There is also evidence that the skin acts as a reservoir. [22] Dermal absorption increases with amount of skin exposed, skin damage, and skin moisture [22] [23] [24] and is greater in some areas of the body than others. [25] Therefore, the behaviors and conditions of tobacco production that promote GTS include wet work conditions and clothing that exposes considerable skin area to nicotine. Transdermal absorption is promoted by the anatomical region exposed, the compromised integrity of the skin, and by climatic conditions.

Epidemiology of GTS

Youth, male gender, working in wet tobacco, and harvesting the crop are suspected risk factors for GTS. [1] [3] [15] Evidence for the efficacy of protective clothing is inconclusive. [1] [5] [9] Tobacco use (smoking or smokeless) seems to reduce the risk for GTS. [1] [3] [15]

Data on GTS incidence or prevalence are quite limited and fail to reflect the current demographics of tobacco work across the United States. Clinical experience and informal interviews with tobacco **farmworkers** and farmers in North Carolina and Kentucky indicate that the disease is widespread and that it results in substantial discomfort for **farmworkers** and economic loss for **farmworkers** and farmers. The earliest estimate of GTS prevalence is reported by Gehlbach et al, who cite their own unpublished data to conclude that "during the 1973 harvesting season, an estimated 9% of North Carolina's 60,000 tobacco growers reported illness among their workers." [2] ,p 478 In 1973, these workers would have been white or African American. For 1992, based on data from Kentucky, the Centers for Disease Control stated, "The estimated crude 2-month incidence rate of hospital treated GTS among tobacco workers in the five-county study area was 10 per 1000 workers." [3] ,p 239 These Kentucky workers were white.

Quandt et al [18] reported the first data on GTS prevalence among Hispanic **farmworkers** in the United States. Using survey interview data collected from 144 Latino migrant and seasonal **farmworkers** at the end of the 1998 tobacco season in eastern North Carolina, Quandt and colleagues found that 41% of their respondents reported having GTS at least once during that season. They point out from these retrospective data that the change from small family farms to larger farms with hired workers who spend whole summers working in tobacco has increased the time at risk for **farmworkers**. They conclude that (1) previous reports from hospital emergency departments or from farmers for their workers seriously underestimate GTS prevalence in **farmworkers**, and (2) it is important to document the rates of GTS among **farmworkers** and risk factors so that appropriate interventions or protections for workers can be developed.

Methods

This study used a longitudinal surveillance design to collect information on the risk factors for and incidence of GTS. Data collection was scheduled at biweekly intervals over a 10-week period.

Sampling

The study was designed to include the random selection of 36 **farmworker** residence sites evenly divided between Wake and Granville Counties, North Carolina. North Carolina is the largest tobacco producer in the United States. In 1998, the state produced 552 million pounds of tobacco, of which 540 million pounds were flue-cured and 12 million pounds were burley tobacco. [26] Both Wake and Granville Counties are in the flue-cured tobacco region and ranked 6 and 15, respectively, of the state's 100 counties in total tobacco production in 1998. [27] These counties were selected because although they are near each other, they differ in the size of farms. Granville is the more northern of the two counties and is characterized by hilly terrain with small farms. Wake is closer to the coastal plain and has flatter terrain and relatively large farms.

Thirty-six sites were randomly selected from lists compiled by the migrant clinics in each county from previous years' experience. The list for Granville County included 72 residence sites, and the list for the Wake County included 110 sites. Preliminary

visits to the 36 selected sites showed that 29 were not in use (18 from Granville, 11 from Wake), and these were randomly replaced. All sites were visited, a census was taken, and preliminary consent was obtained from residents. At no inhabited site did residents refuse to participate. No African American workers and very few women were found to be living at the sites, so random recruitment proceeded at the sites without regard for ethnicity and gender. The original plan called for randomly recruiting five **farmworkers** per site to produce a sample of 180. However, 13 sites had fewer than five residents. At these smaller sites, all **farmworkers** were recruited. For sites with five or more residents: at eight sites, up to seven workers were recruited; at two sites, four participants were recruited; and at 13 sites, five participants were recruited. At the end of the initial selection and recruitment period, the sample included 168 **farmworkers** from 36 sites.

Between the initial period and the first follow-up, one entire site was abandoned by its residents and a 37th site was selected for participation. It also became apparent that there was sufficient turnover of workers at some sites so that some replacement of individuals who had left the area was needed. Therefore, for the third through the final follow-up interview periods, new residents were randomly selected and recruited if more than three sampled residents from that site were reported by other residents to have permanently left the site. If a sampled resident who had not permanently left the site could not be located for an interview within 2 days before and 3 days after the scheduled 2-week follow-up, this interview was not completed.

The total sample included 187 **farmworkers**. However, after examination of the data we found that five of the **farmworkers** had never worked in tobacco during the entire data collection period; therefore, they were not at risk for GTS. These workers were excluded from the final sample. The final sample included 182 **farmworkers**, with 701 data points. The resulting sample included 98 **farmworkers** who were recruited at the first or initial period and from whom data were collected at each of four follow-up interviews. The sample included 16 **farmworkers** who were recruited at the first period but for whom no follow-up interviews were completed, and 50 **farmworkers** who were recruited at the first period and from whom between 1 and 3 follow-up interviews were completed. Finally, the sample includes 18 **farmworkers** who were recruited after the first period with whom one to three follow-up interviews were completed. This sample included 178 Hispanic men, three Hispanic women, and one white man.

Data Collection

Data were collected by three female interviewers. Each had at least a bachelor's degree and was bilingual in English and Spanish. Two interviewers worked together in one county, whereas the other interviewer worked alone in another county. This lone interviewer had been the migrant clinic outreach worker in the previous year, still resided in this county, and was very familiar with her environment and its hazards. Each interview team was supplied with a cellular phone in case of emergency.

The interview questionnaire was developed in English to ensure that all of the topics important to the data collection were included. Questions asked only at baseline (defined as a worker's first interview) included personal and background characteristics, such as age, country of origin, length of residence in the United States, educational attainment, general health, and ability to speak English. Questions asked at each interview for each of the previous 7 days included hours worked in tobacco and type of work, possible risk factors encountered, and symptoms. Other questions obtained data for the previous week on tobacco and alcohol use, actions taken to prevent GTS, and use of health services. Interviewers examined hands and forearms to record the number of cuts, scrapes, and rashes. Respondents self-reported rashes elsewhere on the upper body.

The questionnaire and consent form were translated into Spanish by a professional translator familiar with Mexican Spanish and with **farmworkers** in North Carolina. These forms were then reviewed by native Spanish speakers from Mexico who had been **farmworkers**. Next, the questionnaire and consent form were pretested with eight **farmworkers**. During the pretest, **farmworkers** were first asked to answer an item and then to comment on what the item meant. Based on the pretest results, the investigators and the field interviewers reviewed each questionnaire item and made final revisions.

Interviewing began on June 21, 1999. The data collection procedures were reviewed and approved by the Institutional Review Boards of Wake Forest University School of Medicine; School of Public Health, University of North Carolina at Chapel Hill, and the Centers for Disease Control and Prevention, to ensure the protection of the participants' rights. All participants gave informed consent. The interviewers first visited each site and introduced the project as part of the sample-selection procedure. During the first interview period, sites were visited and specific **farmworkers** were selected and asked to participate. When an individual agreed to participate, the project and the individual's participation were again reviewed and the individual was asked for informed consent to participate. As part of the informed consent and as an incentive at baseline, workers were told they would be given a T-shirt printed with

an occupational health message on avoiding pesticide residues. [28] At the second, third, and fourth interviews, workers were told they would be given health education materials (eg, brochures on HIV/AIDS risks). At the fifth and final interview, participants were told they would be given a hat, again with an occupational health message on avoiding pesticide residues.

The interviews were conducted in the participant's language of choice, with English and Spanish questionnaires available for use. Baseline interviews took about 20 minutes to complete. The initial interview period was completed in 2 weeks in one county but required 3 weeks in the other county. At approximately 2-week intervals, the interviewers returned to each site and conducted the follow-up interviews. Follow-up interviews took approximately 15 minutes to complete. The final follow-up interviews were completed on September 5, 1999. Interviews were normally conducted in the evening after working hours or on weekends. **Farmworkers** typically work on Saturday morning during tobacco season but on Sundays only under extraordinary conditions (eg, weather precluding work during the week with the crop to be either harvested or lost).

Analysis

Frequencies of the demographic characteristics are reported for the 182 **farmworkers** in the sample. The main focus of statistical analysis was estimation of incidence densities of GTS, over the entire data collection period, by segment of the agricultural season, and by GTS risk factors based on the literature. The agricultural season was divided into three parts: early (June 21 to July 18), middle (July 19 to August 8), and late (August 9 to September 5). An occurrence of GTS was defined as any day for which a respondent reported (1) nausea or vomiting, *plus* (2) dizziness or headache, *and* (3) having worked in tobacco that day or the previous day. Because interviews were based on 7-day recalls that were separated, typically, by 1 week from previous interviews, the previous day's status for the earliest day of the recall period was not recorded, so that (3) above was modified to "worked in tobacco that day." Two consecutive days of symptoms and work were counted as one GTS event. A respondent who reported symptoms and work experience for more than 2 consecutive days (3 or 4 days), was considered to have had two occurrences of GTS. For each interview period, the number of GTS occurrences and the number of days worked or at risk for GTS were recorded for each sampled worker. For any subgroup, the incidence density was calculated as the sum of the weighted numbers of occurrences of GTS divided by the weighted numbers of person-days for which workers were at risk, with each summation over all person-weeks contained in the

subgroup. The resulting ratio was multiplied by 100 to give the estimated number of GTS occurrences per 100 days at risk. The weight for a given worker at a given period was determined from the sample survey design (probability of site selection at the first sampling stage, and selection of worker at the second sampling stage) and the rate of non-response due to attrition. Finally, the overall prevalence based on the whole sample and the entire agricultural season was calculated as the number of individuals with at least one GTS occurrence divided by the number of individuals at risk for GTS (had at least 1 day of tobacco work recorded). Prevalence was not calculated for any subgroups, because such comparisons were problematic owing to the differing amount of times at risk.

The GTS risk factors can be divided into two sets: those characteristics that would not change across the study period and were collected only in the baseline interview, and those characteristics and behaviors that might change across the study period and were collected at baseline and each follow-up interview. Baseline characteristics included age, body mass index, educational attainment, ability to understand English, years of tobacco work experience, self-rated health, and status regarding immigration under a work contract (H2A visa). Gender and ethnicity were not considered in this analysis because there was virtually no variability in these characteristics. The follow-up characteristics included type of work with tobacco, skin integrity, recent tobacco use, living with a smoker, recent drinking behavior, working in wet clothing, working without a shirt, wearing a rain-suit, taking measures to prevent GTS, and changing out of wet clothes.

The baseline characteristic body mass index was calculated as weight in kg/(height in meters)^2 from height and weight measurements collected at the initial interview, to which a standard formula was applied. "Understand English" was based on a question that asked respondents to rate their ability to understand English with the categories none, very little, some, most, and all. Only four workers stated that they understood all or most English. Therefore, responses for this measure were collapsed into two categories, "understood some English" and "understood no English." For self-rated health, respondents were asked to rate their health with the categories excellent, very good, good, fair, and poor. These categories were collapsed for the analysis into the two categories "very good, excellent" versus "poor, fair, good."

Type of work was based on the dominant activity reported for a worker during the previous 7 days. "Topping" refers to breaking the flower off the top of the plant. "Priming" refers to picking or harvesting the tobacco leaves. "Barning" refers to putting the harvested tobacco into a barn for curing. "Other" refers to any other activity, such as driving a tractor or not working in tobacco. Skin integrity had the

value "poor" if a worker had a scrape, a rash, or two or more cuts anywhere on the arms or upper torso; the value "good" was applied if a worker had no scrapes or rash and no more than one cut. A respondent was defined as a tobacco user if he or she reported smoking at least one cigarette or cigar or dipping snuff or chewing tobacco at least once per day during the previous 7 days. Consumption of four or more drinks was defined as indicating that one had consumed four or more alcoholic beverages on at least 1 day of the previous 7. "Works in wet clothes" was divided into two categories based on whether a worker had worked in wet clothes at least 25% of the days worked during the previous 7 days. "Changed out of wet clothes when wet" indicated a worker's reported of changing out of wet clothes. "Wears a rain-suit" indicated a worker's affirmative response about wearing a rain-suit to prevent getting sick while working in tobacco. Finally, "takes preventive measures" indicated a worker's affirmative response concerning taking medicine or doing anything else to prevent getting sick while working in tobacco.

Variance estimates for incidence densities were computed using the first-order Taylor series approximation of the deviations of the estimates from their expected values. [29] Corresponding standard errors account for (1) the probability of selection into the sample using weights based on the sampling design; (2) multiple, possibly unequal, numbers of surveys per worker; and (3) intra-site correlation arising from the sampling of groups of workers according to sites where they live. Hypotheses for subgroup comparisons of incidence densities were tested with Wald tests. The results reported here were computed using the RATIO procedure in the SUDAAN software package. [30] Model-based adjusted incidence density estimates were provided to complement the unadjusted Wald tests found to be statistically significant. Generally, subgroup comparisons adjusted for the type of tobacco work and worker smoking status using weighted least squares techniques, which are fully described in a different epidemiological prospective study. [31]

Results

Characteristics of the Study Population

The study participants were homogenous for several important characteristics. They were overwhelmingly male, with only three women in the sample. They were almost exclusively Latino and Mexican. There was one non-Hispanic white participant, and

all of the other 181 participants were born in Mexico. Only two participants (including the non-Hispanic white) stated that they could speak English. All but one of the participants could speak Spanish, although 15 stated that they spoke a non-Spanish, indigenous language at home. Three-quarters (137) of the participants were married or living as married, three were separated or divorced, and 42 were never married. All of the participants were living in housing supplied by the grower for whom they worked.

The study participants were heterogenous in several other social and demographic characteristics (Table 1). They ranged in age from 18 to 64 years, with a median age of 27.6 years. One-quarter of the participants were 18 to 24 years old, 48.9% were 25 to 34, and 31.9% were 35 or older. About half of the participants stated that they understood no English. Almost a third of the participants had fewer than 6 years of education, 35.4% had 6 to 8 years, and 32.6% had 9 to 16 years. The number of years of experience working in tobacco ranged from 1 to 25, with a mean of 4.6 years. Over half (55.3%) of the respondents stated that they had come to the United States on a work contract.

Table 1. GTS ID and Baseline Characteristics*

Value	No. of Workers		GTS Events	Incidence Density	SE	*P* Value
	n	%				
Overall	182	100.0	65	1.88	0.45	
BMI						
<25 (low)	66	36.3	22	1.79	0.56	0.56 (l–m)
25 to <30 (mid)	87	47.8	32	2.09	0.51	0.66 (l–h)
30+ (high)	29	15.9	11	1.49	0.71	0.46 (m–h)
Age						
18–24 (low)	46	25.2	16	2.59	0.91	0.46 (l–m)
25–34 (mid)	78	48.9	28	1.79	0.60	0.17 (l–h)
35+	58	31.9	21	1.55	0.51	0.74

Value	No. of Workers		GTS Events	Incidence Density	SE	*P* Value
	n	%				
(high)						(m–h)
Education						
0–5 years	58	32.0	20	1.65	0.58	0.66 (l–m)
6–8 years	64	35.4	23	1.89	0.54	0.61 (l–h)
9–16 years	59	32.6	21	2.12	0.81	0.80 (m–h)
Understand English						
Some	93	51.1	35	2.09	0.62	0.43
None	89	48.9	30	1.67	0.38	
Years worked in tobacco						
First	59	32.4	24	2.41	0.74	0.89 (l–m)
2–4	75	41.2	29	2.30	0.51	0.048 (l–h)
5 or more	48	26.4	12	0.87	0.44	0.016 (m–h)
Self-rated health						
Very good, excellent	86	47.3	47	2.57	0.69	0.088
Poor, fair, good	96	52.7	18	1.23	0.44	
Work contract						
Yes	99	55.3	41	2.43	0.58	0.27
No	80	44.7	24	1.45	0.66	

* GTS, green tobacco sickness; ID, incidence density; SE, standard error; BMI, body mass index.

GTS Prevalence and Incidence

Of the 182 individuals at risk, 44 had GTS at least once during the data collection period. This resulted in a prevalence of 24.2%. The 44 individuals combined to have 65 different occurrences of GTS during the 3397 person-days (from 660 surveys) when the workers were at risk for GTS. This resulted in an overall incidence density (ID) of 1.88; that is, for every 100 days of work in tobacco, **farmworkers** had GTS for 1.88 days. Ignoring the sampling design, the unweighted ID was 64 of 3397 = 1.91.

Table 2 reports the overall IDs for GTS and the symptoms that were combined to define GTS, along with their IDs for each period of the tobacco season (early, middle, late). The ID for GTS varied across the three periods such that there were greater GTS IDs during the middle (2.34) and later (2.13) summer periods than during the early summer period (0.93).

Table 2. GTS and Symptom IDs*

Type of Event/Period	No. of Surveys	Frequency of Events	ID	SE	*P* Value
GTS					
Overall	660	65	1.88	0.45	
Early (e)	227	10	0.93	0.38	0.055 (e–m)
Middle (m)	208	25	2.34	0.67	0.043 (e–l)
Late (l)	225	30	2.13	0.62	0.78 (m–l)
Nausea					
Overall	660	121	4.52	1.73	
Early	227	18	1.57	0.57	0.046 (e–m)
Middle	208	45	3.85	0.98	0.15 (e–l)

Type of Event/Period	No. of Surveys	Frequency of Events	ID	SE	*P* Value
Late	225	58	6.98	3.68	0.37 (m–l)
Vomiting					
Overall	660	31	1.00	0.31	
Early	227	6	0.59	0.23	
Middle	208	14	1.81	0.93	0.99 (e–l)
Late	225	11	0.60	0.23	0.23 (m–l)
Headache					
Overall	660	264	7.61	1.50	
Early	227	94	9.62	2.71	0.3 (e–m)
Middle	208	79	5.82		0.20 (e–l)
Late	225	91	5.93		0.94 (m–l)
Dizziness					
Overall	660	122	3.72	0.85	
Early	227	13	1.16		0.015 (e–m)
Middle	208	50	4.62	.39	0.007 (e–l)
Late	225	59	4.65	.32	0.99 (m–l)

* For definition of abbreviations, see Table 1

The IDs for the symptoms used to diagnose GTS varied in different ways across the periods. The overall ID for vomiting was 1.00, and its ID did not change significantly across the three periods. The overall ID for headache was 7.61; it declined from the early to the middle and late periods, although this decline was not statistically significant. The overall ID for nausea was 4.52; it increased significantly from the early (ID, 1.57) to the middle (ID, 3.85) periods. However, although there was a further increase in the nausea ID to 6.98 for the late period, this ID was not significantly different from the earlier periods because of the high standard error. The overall ID for dizziness was 3.72; it increased from the early period (1.16) to the

middle (4.62) and late (4.65) periods. The increases in nausea (rather than vomiting) and dizziness (rather than headache) contributed to the increase in GTS across the three periods.

Risk Factors and GTS Incidence

Most of the baseline worker characteristics had no effect on GTS ID (Table 1). These included body mass index, age, education, ability to understand English, and having immigrated under a work contract. Years worked in tobacco had a significant effect on GTS ID such that those who had worked in tobacco for 5 or more years (ID, 0.87) had a significantly lower ID than those who had worked in tobacco for 2 to 4 years (ID, 2.30) or were in their first year (ID, 2.41). The significance of self-rated health is marginal at 0.09 and, contrary to expectation, indicates that those with higher self-rated health had a greater ID for GTS.

Several of the follow-up worker characteristics and behaviors were significantly related to GTS ID (Table 3). Type of work had the strongest association with GTS ID. Those who had done priming as their dominant work activity in the previous 7 days had an ID of 4.04. Those who had primed and barned had an ID of 2.55, and those who had topped had an ID of 1.86. Those who had only barned had an ID of 0.62, whereas those who had been involved in other activities had an ID of 0.24.

Table 3. GTS ID and Follow-up Characteristics*

Value	No. of Surveys	GTS Events	ID	SE	*P* Value
Overall	182	65	1.88	0.45	
Type of work†					
Prime (1)	93	21	4.04	1.24	(1–4) 0.01
Prime/barn (2)	93	13	2.55	0.87	(1–5) 0.01
Top (3)	274	24	1.86	0.60	(2–4) 0.05
Barn (4)	99	5	0.62	0.49	(2–5) 0.01
Other (5)	101	2	0.24	0.25	(3–5) 0.01

Value	No. of Surveys	GTS Events	ID	SE	*P* Value
Skin integrity					
Good	562	53	1.88	0.45	0.99
Poor	98	12	1.89	0.91	
Tobacco use					
Yes	260	17	1.18	0.32	0.021
No	400	48	2.39	0.61	
Live with a smoker					
Yes	470	43	1.71	0.45	0.53
No	189	21	2.16	0.70	
Four or more drinks					
Yes	178	15	1.55	0.40	0.34
No	480	50	2.04	0.54	
Work in wet clothes					
25%+	232	35	2.97	0.71	0.022
<25%	428	30	1.29	0.42	
Change out of wet clothes (when wet)					
Yes	312	40	2.27	0.50	0.90
No	156	19	2.16	0.87	
Work with no shirt					
Yes	38	8	2.29	1.31	0.75
No	622	57	1.85	0.47	

Value	No. of Surveys	GTS Events	ID	SE	*P* Value
Wear rain-suit					
Yes	209	27	2.38	0.76	0.31
No	450	38	1.60	0.41	
Preventive measures					
Yes	51	21	8.10	1.64	<0.001
No	609	44	1.37	0.38	

* For definition of abbreviations, see Table

† Only the significant *P* values among the 10 pairwise comparisons for type of work are reported.

As indicated in earlier reports, tobacco use is associated with reduced GTS incidence. Tobacco use decreased ID by half: those who did not use tobacco had an ID of 2.39, whereas those who used tobacco had an ID of 1.18. Living with a smoker was not associated with ID. Consuming four on more alcoholic drinks on any day in the previous 7 was not related to ID.

Wearing wet clothes significantly increased the incidence of GTS. Those who wore wet clothes for more 25% or more of the time had an ID over twice as high (2.97) as those who wore wet clothes for less than 25% of the time (1.29). Changing out of wet clothes, not wearing a shirt, or wearing a rain-suit to prevent contact with wet tobacco had no significant association with ID.

Skin integrity was unrelated to ID. Taking preventive measures was related to ID but in a direction opposite to expectation. Although few respondents reported taking preventive measures, those taking these measures had an ID of 8.10, whereas those who did not had an ID of 1.37.

Adjusted ID estimates were produced using weighted least squares [31] methods to

assess the potential effects of confounding by type of work and tobacco use on the relationships of risk factors with GTS incidence. Because of the sample-size requirements of the weighted least squares methods and the small number of GTS events in some cells, a five-level effect was evaluated as a confounder that included (1) tobacco users whose dominant activity was priming, or priming and barning; (2) tobacco non-users whose dominant activity was priming, or priming and barning; (3) tobacco users whose dominant activity was topping; (4) tobacco non-users whose dominant activity was topping; and (5) tobacco users or non-users whose primary activity was barning or other. Adjusting for type of work and tobacco use showed that those who had worked in tobacco for 5 or more years had a significantly lower GTS ID than those who had done so for less than 5 years (0.63 vs 1.58; $P = 0.014$). Those with higher self-rated health had a significantly higher GTS ID than those with lower self-rated health (2.12 vs 0.89, $P = 0.002$). Those who wore wet clothes for 25% or more of the time had a GTS ID almost twice as high as that of those who wore wet clothes for less than 25% of the time, although this result was now marginally significant (1.98 vs 1.01, $P = 0.062$). Those taking preventive measures had a significantly higher adjusted GTS ID than those not taking these measures (7.70 vs 1.60, $P < 0.001$). Finally, when adjusting for type of work (with only the categories "barn" and "other," combined, from Table 3), tobacco users had a significantly lower GTS ID than non-users (1.22 vs 2.04, $P = 0.025$). In summary, after weighted least squares methods were applied to multivariate linear models for log IDs, the adjusted effects were similar to unadjusted effects; for example, the ratio of IDs for not using tobacco and using tobacco, respectively, were 2.45 of 1.23 = 1.99 (unadjusted) and 2.04 of 1.22 = 1.67 (adjusted).

Discussion and Conclusions

Our study provides the first prospective surveillance data on the prevalence and incidence of GTS in any population. It documents that GTS is a highly prevalent occupational illness among Latino migrant and seasonal **farmworkers** in North Carolina. Over the course of the 10-week data collection, 24.2% of 182 at-risk **farmworkers** whom we interviewed had GTS at least once, with these 44 individuals experiencing a total of 65 occurrences of GTS. The incidence of GTS was such that **farmworkers** suffered from GTS for almost 2 days for every 100 days they were at risk.

The prevalence rate of 24.2 may be lower than the actual rate. We collected data through the first week of September. Tobacco harvesting in some parts of central North Carolina does not conclude until late September. Therefore, it is likely that the rate would increase if the project design had allowed for continued data collection. Further, during the data collection period, the project field staff made at least five visits to each site and became familiar with the workers. The staff learned of individual workers who came to work at the site but became ill and left after only a few days. For example, at one site visited on a Thursday, the field staff learned that six new workers had joined the crew on Monday (replacing workers who had become sick and left). These replacement workers had become sick on Monday and moved from the area on Tuesday, giving them no chance to participate in our study. There is no way to quantify this more ethnographic information, but it does lead us to believe that the actual prevalence and incidence density (ID) may be higher than we could detect.

This overall incidence rate of 1.88 per 100 days of work varied across the season and with the specific tobacco production tasks in which the individual worker was involved. Inasmuch as the production tasks also varied across the season, these two factors were related. The ID was lowest (<1) early in the season. The production tasks in which workers were most engaged early in the season were topping the plants and "other work," and topping and other work were associated with relatively low ID. The ID for the later two-thirds of the season was greater than 2. Later in the season, the dominant production tasks were harvesting (priming) and curing (barning) the tobacco. The ID for workers with greater involvement in priming was over 4, whereas those whose work was split between priming and barning had an ID of 2.55. Priming flue-cured tobacco puts workers in greatest contact with nicotine. Workers break off ripe leaves and hold them under their arms as they move down the rows until they can hold no more. As the day progresses, their shirts and skin are stiff with sticky tobacco juice. The axilla is the most likely of any skin area to absorb chemicals. [25]

Several factors in addition to period of the season and production task had a strong effect on the ID of GTS. The first of these was work experience. Those with more than 5 years of tobacco work experience had an ID smaller than one-half that for those with less than 5 years of experience. The reason for this effect is unclear. It could indicate that through experience in working with tobacco, the individual worker learns how to avoid the causes of this occupational illness. Nevertheless, whatever the causal relationship, the increasing number of new workers recruited to meet the labor shortage in agriculture and other industries in North Carolina suggests that the incidence of GTS will remain high.

Working in wet tobacco or wearing wet clothing is a GTS risk factor that was identified in earlier reports. [3] [15] [17] We found that workers who reported working in wet clothing for 25% or more of the days they worked in tobacco had an ID over twice that of those who worked in wet clothing less often. This is important, because workers have some control over the length of time they remain in wet clothing; they could bring a second set of clothing to work and change into dry clothing. Further, employers could provide a garment that keeps the wet tobacco off the skin. We found that one approach often used to keep workers from exposure to wet tobacco, wearing a plastic rain-suit, had no effect on GTS ID. These rain-suits are often provided by employers. Why wearing rain-suits had no relationship to ID in this analysis is unclear. It could be that workers did not wear them consistently, or that because of the heat they were worn with the jacket open rather than closed, or that because of the open cuffs water containing nicotine was wicked up the sleeves.

We also found that those who used tobacco products (mostly cigarette smoking) had GTS ID of less than half that of those who did not use tobacco products. This again verifies earlier reports. [1] [3] [15] Although the actual mechanism of this protective effect is not clear, [18] studies of transdermal nicotine patches indicate that circulating nicotine blocks absorption. [32] Of course, it would not be responsible to encourage workers to use tobacco to avoid getting GTS, because we know that tobacco use will increase the risks of these workers for a large number of illnesses that are much more serious than GTS.

Finally, contrary to expectation, workers who told us that they took preventive measures to keep from getting GTS had an ID 6 times that of those who did not tell us they took preventive measures. It is likely that these "preventive measures" are being taken by workers in reaction to the illness.

There are some limitations to the statistical analysis we used. The sampling weights used make several assumptions about the sample and the population. First and foremost, we assumed that our sample represented a cohort of a population that was static over time, when in actuality, significant in-and-out migration was known to occur in the study area. Also, the sample weights relied on the number of sites enumerated in the population for each of the two strata (regions), but even these values changed as the status of sites changed from active to inactive or vice versa. Next, adjustments to the sampling weights for non-response due to dropout were crude in that they were based on only a few strata, owing to the small number of workers in each site. Despite these challenges, weighting had little effect on the estimation of IDs; the unweighted (or all weights equal to 1) overall ID was 1.91 compared with the weighted value of 1.88 reported in Table 2. The weighted least

squares techniques, although useful for characterizing IDs in a sample survey setting, allow simultaneous consideration of only a limited number of variables. In addition, all variables including covariates must be categorical. More elaborate multivariate analyses, allowing for continuous covariates and making different assumptions will be pursued elsewhere.

Conclusion

Even with these limitations, these results indicate that those who harvest tobacco are at great risk for GTS. Tobacco harvesters in the United States or in other countries include those who profit least from the tobacco industry (**farmworkers** and small farmers). Although they are at risk from occupational illness such as GTS and exposure to occupational toxicants such as pesticides, [33] these workers have limited control over workplace safety. There are no long-term data to assess the risk of repeated nicotine poisoning that workers may experience. Reducing **farmworkers'** risk for GTS is an issue of environmental justice that must be addressed.

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