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Migrant Farmworkers and Green Tobacco Sickness: New Issues for an Understudied Disease

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Background *The transition from family tobacco production to dependence on hired labor has placed migrant and seasonal farmworkers (MSF) at risk for green tobacco sickness (GTS). No previous studies of GTS have focused on MSF.*

Methods *One hundred and forty-four Hispanic MSF working in tobacco production in North Carolina were surveyed to obtain self-reports of GTS, preventive behaviors, and treatments.*

Results *Forty-one percent reported having GTS at least once during the summer. Most had taken no precautions to prevent GTS. Ninety-six percent of those with GTS had tried to treat it. Antinausea medications were the most common treatments. Only 9% sought medical treatment; 7% lost work time.*

Conclusions *The incidence of GTS obtained by interviewing MSF is much higher than that in other studies, which have relied on rates of medical treatment or farmers' reports for their workers. MSF constitute a population at risk for GTS who have little control over work conditions to prevent GTS or seek treatment.* Am. J. Ind. Med. 37:307–315, 2000. © *2000 Wiley-Liss, Inc.*

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INTRODUCTION

Green tobacco sickness (GTS) is a condition that has long been known as an occupational health risk among tobacco farmers. It is characterized by headache, nausea, and dizziness; and it occurs after working in wet tobacco fields. Tobacco is produced across a large segment of the U.S., stretching from Florida to Connecticut. In 1997, U.S. farms produced 1.6 billion pounds of tobacco on over 700,000 acres. In the largest producing state, North Carolina, over 684 million pounds of tobacco were produced on 314,000 acres [North Carolina Cooperative Extension Service, 1998a, 1998b]. Despite the widespread production of tobacco and risk for GTS, the medical literature on GTS is exceedingly slim. There are fewer than 30 published papers on GTS in the medical literature. Several of these are reports of single cases [Edmonson and Smith, 1996; Ives, 1983] or review articles [Hipke, 1993]. Only two of these papers contain any research-based information about how GTS can be prevented [Gehlbach et al., 1979; Ghosh et al., 1987]. Only one case study reports successful treatment of GTS symptoms [Ives, 1983].

GTS was first described in 1970 among tobacco workers in Florida and presumed to be due to a chemical other than nicotine in the green tobacco gum [Weizenecker and Deal, 1970]. Since then, GTS has been linked to

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nicotine and symptoms attributed to acute nicotine poisoning following dermal contact with mature tobacco plants, *Nicotiana tabacum* [Gehlbach et al., 1975]. Common symptoms are nonspecific (e.g., weakness, nausea, vomiting and dizziness [Gehlbach et al., 1974, 1975]), and there are no established diagnostic criteria. Other frequently encountered symptoms include abdominal cramps, headache, breathing difficulty, pallor, increased sweating and salivation, chills, and fluctuations in blood pressure or heart rate. GTS usually occurs in the afternoon and evening, several hours after exposure [CDC, 1993; Gehlbach et al., 1974; Ballard et al., 1995; McKnight et al., 1996a]. It is self-limiting, with recovery within one or two days after the onset of symptoms. However, symptoms are often severe enough to result in dehydration, the need for emergency medical treatment, and loss of work time.

U.S. tobacco production is rapidly moving from small family-farm holdings to large consolidated operations worked by seasonal and migrant farmworkers. This change in production has placed a new group of workers—seasonal and migrant farmworkers—at risk, and has changed the nature of the risk for GTS. The purpose of this paper is to: (1) present a biobehavioral model for exposure to the risk factors for GTS among farmworkers, based on the limited existing research on symptoms, risk factors, and treatments, and (2) present data on the incidence of GTS symptoms from a survey of seasonal and migrant farmworkers in North Carolina that demonstrate the possible extent of this occupational and environmental health risk. The likely burden of GTS experienced by farmworkers, their lack of knowledge about the condition, and barriers to personal control of conditions in the workplace make GTS an environmental justice issue, part of the growing concern that poor, minority, and medically underserved populations bear a disproportionate burden of the negative health consequences of environmental and occupational health risks [Brown, 1995; Sexton and Anderson, 1993; Olden, 1998]. By framing GTS as an environmental justice issue, this paper calls for research to develop means of preventing or reducing the risk of GTS in this population newly at risk.

Biology and Pharmacokinetics of Transdermal Nicotine Absorption

The symptoms of GTS are thought to result from the complex physiological effects of nicotine. This alkaloid can either stimulate or desensitize receptors in the autonomic ganglia and peripheral nerve endings, causing nausea, vomiting, and variable effects on blood pressure and heart rate. It increases the release of epinephrine by the adrenal gland, resulting in increased blood pressure and heart rate. Finally, it acts directly on the brain to cause generalized stimulation, tremor, and activation of the emetic chemoreceptor trigger zone, causing vomiting [Hardman et al., 1996].

Nicotine is readily absorbed through the skin. The skin acts both as a barrier and as the primary route into the systemic circulation for chemicals. The physico-chemical properties of nicotine lend it to transdermal absorption: it is a small molecule soluble in both water and lipids. The surfaces of wet tobacco leaves contain nicotine. When coming in contact with human skin, this nicotine diffuses easily across the stratum corneum and then through the lower skin layers to where it is taken up by blood vessels [Guy and Hadgraft, 1989].

Studies of absorption kinetics have shown variation in chemical absorption by anatomical site. Compared to the ventral forearm, some sites absorb less (palm, 83%; plantar surface of foot, 14%), while other sites absorb considerably more (back, 170%; axilla, 360%; forehead, 600%) [Feldmann and Maibach, 1967]. Comparison of several types of nicotine administration (smoking, transdermal, nasal spray) shows that absorption through the skin produces the most consistent plasma levels [Benowitz et al., 1997].

There is also evidence that the skin acts as a reservoir [Benowitz et al., 1987] so that plasma levels decline with mean elimination half-life of over 4 h after exposure [Keller-Stanislawski et al., 1993]. Absorption increases with the amount of skin exposed and 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]. Dermal absorption of chemicals increases linearly with skin moisture [Meuling et al., 1997]. Reduced absorption of nicotine through the skin has been observed in studies giving a simultaneous plasma infusion of nicotine, suggesting that the vasoconstrictive effect of the infused nicotine blocks uptake of transdermal nicotine by the dermal blood vessels [Benowitz et al., 1992]. Thus, nicotine from nonskin sources (smoking or chewing) may reduce transdermal nicotine absorption. Other conditions that regulate vasodilation (e.g., hot or cold temperatures, alcohol consumption) may similarly affect nicotine absorption.

Figure 1 synthesizes the biological literature on transdermal absorption of nicotine and general chemical absorption kinetics with behaviors and conditions of tobacco production to describe the factors promoting and preventing GTS. Wet work conditions and clothing that exposes considerable skin area promote the dermal exposure to nicotine. Transdermal absorption is promoted by the anatomical region exposed, the compromised integrity of the skin, and by climatic conditions.

Changing Tobacco Production and Dermal Exposure to Nicotine

Tobacco farming, like much of U.S. agriculture, has become commercialized. Until the 1970s, most tobacco was

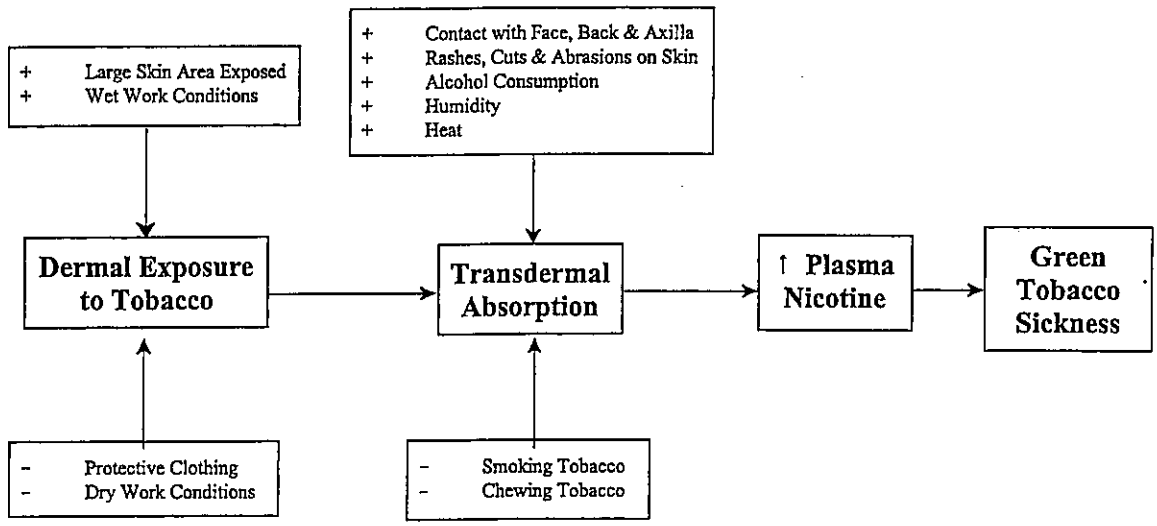

FIGURE 1. Bio-behavioral pathway by which dermal exposure to wet tobacco leads to Green Tobacco Sickness.

grown on family farms with allotments of a few acres [van Willigen and Eastwood, 1998; Collins and Hawks, 1993]. Today, maintaining a viable income from tobacco requires a much larger production base, acquired through lease or purchase of other land owners' allotments. With a concentration of production among fewer farmers, hired labor must be employed in tobacco production. Therefore, instead of family groups with a few workers doing a relatively small amount of tobacco work, there are now hired, low-paid, usually minority workers working in tobacco almost exclusively for 8–12 weeks each year. These workers are exposed to the risks of tobacco work for longer, more intensive periods of time than was ever the case for farming families. If the proposed national tobacco settlement to eliminate the current federally-legislated system of production quotas for farmers is enacted, it is likely that tobacco production will be further concentrated on large farms with low cost labor. Over the past decade, farmworkers doing tobacco work in the US increasingly have been Hispanic. This reflects the transformation of the national migrant and seasonal labor force from one that a decade ago was racially and ethnically diverse [Mines et al., 1991] to a current labor force that is overwhelmingly Hispanic [Mines et al., 1993, 1997] and foreign born, primarily from Mexico [Mines et al., 1997].

Burley and flue-cured are the two primary varieties of tobacco produced in the US. Several production tasks result in exposure of workers to the wet leaves. For both types of tobacco, the flower must be cut from the growing plant (topping) to cause an increase in root growth and greater leaf weight and nicotine content at harvest [Collins and Hawks, 1993]. To do this, workers walk down the rows of 4–6 foot high tobacco plants and break off the flowers at the top. Workers are brushed by the bushy leaves as they walk down the rows and as they reach into the plants to break off the flowers. Topping is usually completed in the first two weeks of July. Production research has determined that more closely spaced rows increase the production poundage [Collins and Hawks, 1993]. This also results in greater contact between the plants and the workers.

Burley tobacco is harvested as a whole stalk, requiring workers to reach under the large plant and cut the stalk. Stalks are impaled on sharp sticks in the fields to begin the process of air-curing [van Willigen and Eastwood, 1998].

The harvest of flue-cured tobacco presents the greatest opportunity for exposure to wet tobacco leaves. Priming or cropping (picking the tobacco leaves) is done in stages as the leaves become ripe or prime for harvest. First the bottom leaves are picked. Again, workers must walk through the rows, reach into the plants, and break off the bottom leaves. In this process, the entire body is engulfed in green tobacco leaves. The picked leaves are held under the arms as more tobacco is picked until no more can be carried; the tobacco is then placed in a cart. Tobacco is transferred by hand from carts to tobacco barns in which it is heat-cured. The middle leaves are then picked in the same manner as they become ripe. Finally, the top leaves are picked. Priming usually begins in mid-July and is completed in mid-September; 3–10 primings are completed in each field.

Topping and priming work starts in the early morning when the plants are wet with dew, and workers' clothing quickly becomes soaked. The juices of the tobacco plants form a thick gummy layer that congeals on the workers' clothing or skin. Workers often remove their shirts in the afternoon work hours, directly exposing the skin to the tobacco leaves and juices. Both topping and harvesting tobacco result in cuts and abrasions to the skin. Workers find protective gloves a hindrance, as they become stiff and

sticky with the tobacco juice. The summer heat and humidity in the fields make gloves and other protective clothing extremely uncomfortable.

Efforts have been made to mechanize tobacco harvesting, but this is difficult because the leaves mature at different rates and the machinery is expensive. A ripening agent must be sprayed on the plants so that they are all ripe simultaneously for mechanical harvesting. Leaves picked mechanically are of lower quality and bring a lower price than leaves that are hand picked. Hence, hand harvesting remains the preferred method.

Epidemiology of Green Tobacco Sickness

Data on GTS incidence are quite limited and fail to reflect the recent changes in migrant and seasonal farmworker involvement in tobacco production across the U.S. The earliest estimate of GTS incidence is reported by Gehlbach et al. [1975], 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." In 1973, these workers were predominantly white or African-American, not Hispanic, and no information is given on the number of farmworkers at risk. For 1992, based on data from Kentucky, the Centers for Disease Control (CDC) 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" [CDC, 1993:239]. These Kentucky workers were predominantly white; many were family members (including children) working on small family farms.

GTS cases are often spatially and temporally clustered, with several cases occurring on the same farm on the same day [Gehlbach et al., 1974; McKnight et al., 1994, 1996a, 1996b]. The causes of clustering are not clear. It is possible that individuals working in the same conditions (e.g., wet tobacco), who are dressed the same (e.g., shirtless), picking tobacco with the same properties (e.g., nicotine content) will be affected by this occupational disease simultaneously. There may also be a group effect, that is, a single individual recognizes symptoms common to several persons in the work group as GTS, and they decide to seek medical care together. Since many of McKnight et al.'s clusters were families [McKnight et al., 1996a, 1996b], there may be a genetic component to GTS as well, perhaps variants in nicotine metabolism. Although race and ethnicity are not reported for these familial clusters, all are in Kentucky where tobacco is harvested on small family farms [McKnight et al., 1996a] and the rural population is almost entirely white.

Several factors have been proposed as risk factors for GTS. Young age has consistently been found to increase the risk of GTS [Gehlbach et al., 1974; CDC, 1993; Ballard et al., 1995]. Since most research has been conducted on white farmers, it is impossible to determine with the existing data if ethnicity affects risk [Gehlbach et al., 1974]. GTS symptoms have been reported among tobacco workers in India [Ghosh et al., 1979] and Japan [Misumi et al., 1983], indicating that it is not specific to white Americans.

Gender has been found by some to affect GTS risk, with males being at greater risk [Gehlbach et al., 1994]; however, this might result from a division of labor that results in males having greater contact with the tobacco. CDC [1993] and Ballard et al. [1995] found no difference by gender. Actually picking (cropping, priming) the tobacco, rather than housing it, appears to increase the risk of GTS [Gehlbach et al., 1974]. Working in tobacco wet from morning dew or rain, rather than dry tobacco, increases the risk [CDC, 1993; Ballard et al., 1995; McKnight et al., 1996a]. Finally, tobacco use (smoking or smokeless) seems to reduce GTS risk [Gehlbach et al., 1974; CDC, 1993; Ballard et al., 1995].

There is considerable anecdotal information on interpersonal variability in sensitivity for GTS. Weizenecker and Deal's original report of GTS differentiated "reactors" and "nonreactors" [1970]. Some individuals tend to get GTS every year, but others do not. When tobacco farms were family operations, those who were most susceptible to GTS could be assigned to work tasks other than those in tobacco. However, hired farmworkers do not have this option. Many current farmworkers believe that they could be fired if they get sick or work too slowly [Austin et al. unpublished communication]. It is not clear if specific individuals tend to get GTS several times in a season, or if they build up tolerance.

Other than a single case report [Ives, 1983], none of the limited GTS incidence literature has considered Hispanic farmworkers. While African-American farmworkers have worked in tobacco production since the beginning of commercial agriculture in the southeast U.S., there is also almost no information in the literature on GTS incidence in this population. Gehlbach et al. [1974] conclude that the lack of cases reported for African-Americans is "probably related to inequities in the reporting of illness. Because most tobacco sickness occurs after working hours, and most of the growers interviewed were whites who have little interaction with blacks after work, farmers may have been unaware of illnesses that occurred."

MATERIALS AND METHODS

Data were collected during a survey of seasonal and migrant farmworkers conducted for another occupational health study [Arcury et al., 1999a, 1999b; Quandt et al., 1998]. Respondents were farmworkers employed in an eight county area in central North Carolina during the summer of 1998. A two stage approach was used to locate and recruit

respondents. The sampling and recruitment strategy was based on the need to maximize the representativeness of the sample, while taking into account the realities of studying occupational health of a largely undocumented, relatively "invisible", and highly mobile population [Arcury et al., 1999a]. Because the number of farmworkers and their distribution in the state of North Carolina, as in many states, is unknown, there is no available sampling frame. Based on information obtained during formative research [Quandt et al., 1998] and that provided by the North Carolina Farmworkers' Project (a community-based organization serving farmworkers), it was known that workers could be located in a variety of residential sites, including on-farm labor camps, trailer parks, old farm houses, and apartments. It was also known that workers within housing sites were likely to be more similar to each other (e.g., same towns of original, same current employer, members of same families) than to workers in other housing sites. Therefore, the first stage of the sampling plan was intended to maximize representativeness of the sample by selecting a broad range of sites. A site was defined as a residential locale in which all or most residents were farmworkers and their families. To identify as many sites as possible, community representatives connected with the North Carolina Farmworkers' Project helped to create a list of potential sites. They did this based on their knowledge as area residents, by community reconnaissance, by interviewing farmers, and by talking with farmworker service providers. The next step was to visit each site and ascertain that the farmworkers present would be willing to participate in the study, if asked. This visit was primarily intended to familiarize farmworkers with the existence of the study. Community members, Hispanic and former or present farmworkers, were hired and accompanied the project coordinator on site visits. The research staff then selected different kinds of sites from those visited, including large and small labor camps, trailer parks, and rental housing. The study sample included 35 sites. At two sites, residents were H2A workers, workers who enter the United States on a special visa program that permits them to work only for a specific farmer and requires them to return to Mexico when the farmer terminates their employment. Workers at these two sites stated that they would not participate due to concern about reprisals from their employer. These two sites were replaced.

As a second sampling stage, up to ten farmworkers were recruited at each site. In 24 of the 35 sites, 10 or fewer workers were present. In the others, respondents were selected according to the following protocol. After a brief general presentation to the group, the interview team leader identified 10 workers to be interviewed. The criteria used were to first select any women present, and then to select a range of ages from those present. Using this system of multiple contacts leading up to recruitment familiarized farmworkers with the project; there were very few refusals at the stage of actual recruitment.

Using this two-stage method, 270 farmworkers were recruited early in the farming season (late June to early July). From this pool, 162 (60%) could be located, and agreed to be interviewed at the end of the summer (late August to early September). As might be expected with a population that migrates, many of those lost to follow-up had left the area for work elsewhere. In some cases, there had been almost a complete turn-over in workers at a site. In others, single workers had left.

Interviews were conducted in Spanish at the residential sites after work hours. All questionnaires were administered verbally, and answers were recorded by the interviewer. Interview teams consisted of a research project staff member, a college student, and former farmworkers. The college students were fluent in Spanish. The former farmworkers were originally from Latin America and currently live in the study area. Students and former farmworkers received training in interviewing at two three-hour sessions at the North Carolina Farmworkers' Project office. Interviewers were observed in the field, and data collection forms were field-edited by supervisory staff to ensure data quality.

Data collected included (1) respondent demographic data, including age, gender, permanent residence, and country of origin; (2) farm labor experience, including years worked in U.S. agriculture, and weeks worked in tobacco during current summer; (3) experience of GTS symptoms during the current summer; and (4) efforts to prevent or treat GTS. All GTS and summer tobacco experience data were collected at the second interview. Prevention and treatment options were drawn from existing epidemiological studies of GTS. They were presented as fixed response questions. Farmworkers were given the opportunity to list "other" behaviors. Farmworkers were defined as having had GTS if they responded positively when asked if they had experienced any illness from working in tobacco. There are no specific diagnostic criteria for GTS in the occupational health literature, aside from exposure to tobacco prior to onset of symptoms. Since our qualitative, formative research indicated that workers were generally familiar with GTS once they had worked in tobacco (whether or not they had experienced GTS themselves), we chose to use this somewhat general measure.

Data analysis included producing frequencies describing bivariate relationships of whether or not a farmworker reported GTS by various preventive measures taken. Statistical significance defined with $P<0.05$ was determined with chi-square tests for 2×2 tables, or in the case of sparse data, Fisher's exact tests. For farmworkers reporting GTS, the frequencies of various treatments reportedly used were summarized.

RESULTS

Of the 162 farmworkers interviewed, 144 (89%) reported working in tobacco during the current summer. These 144 constitute the sample at risk for GTS, so all further results are based on this group of farmworkers. They included 127 (88%) males and 17 (12%) females, and ranged in age from 16 to 58 years, with an average of 29.1 years. 141 (97.9%) were from Mexico. Experience in U.S. agriculture ranged from less than 1 year to 20 years, with a mean of 3.56 years (SD = 3.27).

When asked if they had experienced any illness from working in tobacco, 59 responded yes, for a crude incidence rate of 41%. Females were less likely than males to report GTS (35% vs. 42%), though the difference is not significant. Reported frequency of the illness ranged from once during the summer to everyday. Of those reporting GTS, 24% reported that they had experienced the condition once during the summer, 33% twice, 22% three times, and 21% four or more times.

Over half the workers reported taking no precautions to prevent GTS (Table I). The most frequently reported preventive measure was wearing a long-sleeved shirt, reported by 12% of farmworkers. Taking some kind of medication and wearing protective clothing were the next most commonly reported preventive behaviors. Approximately 15% of the workers reported a preventive measure that was classified as "other" because the answer was too vague to classify (e.g., "protect myself", "take precautions") or because it was unique (e.g., "wash the face so sweat does not go in the mouth").

A comparison of those reporting GTS and those reporting no GTS revealed several differences in preventive behavior (Table I). Those who reported GTS were significantly more likely to report having worn a long sleeve shirt or having taken a medication for prevention than those who did not report GTS. Those not reporting GTS were significantly more likely to report having worn protective clothing or drinking milk.

TABLE II. Treatments that Farmworkers with GTS (n = 55[a]) Reported Using for Symptoms Experienced While Working with Tobacco in North Carolina, 1998. Percentages Sum to More than 100 Because More than One Treatment Could Be Marked

Treatment	n	%
One or more treatments	53	96.4
Anti-nausea medication	34	61.8
Lying down	7	12.7
Drinking milk[b]	7	12.7
Seeing a health care provider	5	9.1
Not working for a day	4	7.3

[a]Missing data for 4 farmworkers who reported GTS.
[b]Response to open-ended questions.

Of those who reported GTS, 96.4% reported taking one or more actions to treat the symptoms (Table II). The most commonly reported treatment was taking an antinausea medication, reported by 61.8% of the farmworkers experiencing symptoms. Other treatments were used by only a few farmworkers. Only 9.1% sought treatment from a doctor or at a clinic. Approximately 7% reported losing a day or more of work due to GTS symptoms.

DISCUSSION

This is the first survey research to document GTS as an occupational health risk among seasonal and migrant farmworkers. The data are based on self-reports of having become ill as a result of working in tobacco. They suggest

TABLE I. Preventive Measures for Green Tobacco Sickness (GTS) Reported by Farmworkers Working with Tobacco, North Carolina, 1998: Total Sample, Farmworkers with GTS, Farmworkers with No GTS Reported

	Total (n = 144)		GTS (n = 59)		No GTS (n = 85)		
Preventive measure	n	%	n	%	n	%	P
Nothing	77	54.2	29	49.2	55	64.7	.063
Wearing long-sleeved shirt	17	12.0	12	20.7	5	6.0	.001
Medication	12	8.5	11	19.0	1	1.2	.001
Wearing protective clothing	10	7.0	1	1.7	9	10.7	.048
Drinking milk[a]	7	4.9	0	0.0	7	8.2	.042[b]
Not drinking water[a]	2	1.2	0	0.0	2	1.7	.510[b]
Changing wet clothes	2	1.2	2	3.5	0	0.0	.170[b]
Other[a]	22	15.3	9	15.3	13	15.3	.990

[a]Responses to open-ended question.
[b]Fisher's exact test.

that the incidence of GTS among migrant and seasonal farmworkers is far higher than that reported in other studies. A GTS incidence rate of 10/1000 workers was calculated from emergency room admissions in central Kentucky [CDC, 1993]. Gehlbach et al. [1975] reported that 9% of growers knew of workers who had GTS. While no data were collected on the severity of GTS in the present study, a majority of farmworkers experiencing GTS reported that they had experienced GTS more than once in the season. Almost all of the farmworkers with GTS had tried to treat it.

There are several reasons why the incidence estimates from this study are higher than those reported previously. First, this study surveyed workers, rather than relying on emergency room samples [CDC, 1993] or interviewing farmers [Gehlbach et al., 1975]. Using the rates reported for seeking treatment by workers in the present study, one can estimate the effect of using such data collection designs. Only 3.5% of all farmworkers interviewed reported seeking GTS treatment in a clinic, and 2.8% reported losing a day's work. Thus, surveys based on farmworker clinic visits or on interviews with employers would have produced GTS rates more in line with previous studies. This suggests that the design of previous studies produced underestimates of GTS by failing to count farmworkers who treat GTS through self-medication or other self-care practices or who work despite their GTS symptoms.

A second reason for the higher rates is suggested by the conceptual model. Over half of the workers in this sample are in their first or second year of farm labor in the US. Therefore, these workers are relatively unfamiliar with GTS, in contrast with farmworkers or farmers who have worked in the crop for a long time or come from tobacco-farming families. More experienced workers may have developed behavioral strategies for minimizing exposure to wet tobacco. If it is possible to develop tolerance for dermally-absorbed nicotine, current farmworkers may not have had the time to do so. Body size, another component of the model, may also be important. Although height was not measured in this study, most of the farmworkers in this population are from southern Mexico and on an average are quite a bit shorter than white or African American fieldworkers, making the dermal area through which nicotine can be absorbed high relative to body volume. Thus these workers may experience more effects of nicotine exposure than subjects in other studies.

A third reason for the high rate of GTS among migrant and seasonal farmworkers may lie in the changing production system for tobacco. As small allotments worked by families have given way to a concentration of allotments farmed by a single grower with hired labors, individual workers are now exposed to tobacco for more hours on more days per season than ever before. The farmworker population working in tobacco farms has changed from white and African American to almost entirely Hispanic and foreign-born. These workers speak little or no English. They also lack control over their work circumstances to take steps to limit exposure to wet tobacco. These might include waiting to enter the fields until the tobacco has dried, or wearing protective clothing such as gloves or rain gear. Because both these preventive measures would reduce productivity through reduced work hours or through the use of hot, cumbersome clothing, seasonal and migrant farmworkers might be reluctant to adopt them.

Since the data for these analyses were collected in the context of another study, there are a number of limitations. First, it was not possible to administer a lengthy questionnaire on GTS. Therefore, specific symptoms of GTS were not queried, nor were all risk or protective factors such as smoking status. As a consequence, it is not possible to do a thorough epidemiological analysis of GTS from these data. For example, while some of the precautions taken would probably be effective (e.g., protective clothing), others listed by farmworkers would probably not be helpful (e.g., drinking milk). It is not possible to know why farmworkers report using them. Second, the sample of 162 is truncated; it is 60% of a sample drawn in a manner to produce a representative sample of farmworkers, although there is no objective way of assessing this because of the nature of the farmworker population. It is not possible to know how representative the 162 are of farmworkers who worked in tobacco in 1998. A strength of the sampling strategy, however, is that it excludes farmworkers who may have worked only briefly with tobacco late in the season and, therefore, not been at risk of GTS for the entire season. Because of the cropping system for flue-cured tobacco, farmworkers in North Carolina are at risk over a long period of time, in contrast to burley tobacco production (e.g., in Kentucky as described in McKnight et al. 1996a, 1996b). Because no GTS questions were asked at the initial interview, it is unlikely that hesitation to talk about GTS would have contributed to not participating in the final survey. A weakness of the sample is that it excludes any farmworkers who became so sick from GTS that they quit work. Both farmworkers and farmers in the study area reported that there were a few farmworkers who had such severe symptoms that they "had to go back to Mexico." Another limitation is that no data on tobacco smoking were collected. Since other studies have suggested that smoking is protective against GTS, the relatively high rate of GTS found here could reflect low rates of tobacco smoking. While observation of farmworkers during data collection indicated that some farmworkers smoke, there is no way to estimate its prevalence.

Studies of farmworkers and environmental hazards other than GTS have shown that farmworkers perceive that they have little power to prevent exposure, fearing that failure to work as directed by an employer will result in loss

of employment [Arcury and Quandt, 1998b; Austin et al., unpublished communication; Grieshop, 1997; Grieshop et al., 1996; Lantz et al., 1994; Vaughn, 1993a, 1993b, 1995]. Their lack of power is symptomatic of the larger issue of environmental justice. There is a growing recognition that the health consequences of environmental and occupational risks are disproportionately borne by disenfranchised and medically underserved populations [Brown, 1995; Sexton and Anderson, 1993]. As Kenneth Olden, Director of the National Institute of Environmental Health Sciences states:

> While behavioral and lifestyle factors, nutrition, and access to health care services are important contributors to the increased morbidity and mortality among socioeconomically disadvantaged populations, environmental and occupational exposures—over which these individuals have little control—are likely to play a prominent role. Where one lives and works is less a matter of choice than a result of one's socioeconomic status. Thus, people in the lower socioeconomic strata are more likely to live in the most hazardous environments and to work in the most hazardous occupations, a fact that would be reflected in greater health risk [Olden, 1998].

Recommendations for Further Research

A thorough study of farmworkers is needed to better document the incidence of GTS. Such a study should collect data on a representative sample of farmworkers over the course of the work season to avoid problems of recall. Criteria for differential diagnosis should be developed and used across future studies.

The economic impact of GTS should be studied. While medical treatment costs have been estimated [CDC, 1993], the occupational costs of GTS are unknown [McKnight et al., 1994]. It is obvious that such costs exist for both farmworkers and farmers. Workers lose income for the days they are ill; those who become the most ill may be unemployed for much of the work season. Incapacitated workers mean that a farmer risks losing part of a crop because of labor shortage at critical fieldwork times. However, because farmworkers may be easily replaced, it is farmworkers who may well bear most of the economic risk of GTS.

Interventions need to be developed and tested for their efficacy in preventing or treating the symptoms of GTS. These need to be appropriate to the work environment. For example, use of dimenhydrinate has been reported in a case study [Ives, 1983], and diphenhydramine and meclizine have been used prophylactically in North Carolina migrant health clinics. However, these can induce drowsiness, resulting in another workplace safety risk. Some clinicians in North Carolina report having used transdermal scopolamine with improvement in their patients' symptoms [D. Norton, unpublished communication], but this has not been studied empirically.

Finally, no information is available on any long term health effects of chronic exposure to dermally absorbed nicotine. For farmworkers who are already at risk for a number of work-related health problems (e.g., dermatitis, cancer, infertility) and who suffer from other morbidity and mortality risks (e.g., pesticide poisoning, tuberculosis, HIV, drowning) at rates higher than the general population [Arcury and Quandt, 1998a; Ciesielski et al., 1991; Moses et al., 1993; Zahm and Blaire, 1993], nicotine exposure and GTS may add to this burden of disease and contribute to long term health problems.

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