Epidemiology of Dermatitis among California Farm Workers

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To estimate the prevalence of dermatitis and risk factors for skin disease in California farm workers, a cross-sectional survey was conducted among grape, citrus, and tomato workers. The prevalence of contact dermatitis was 2% and lichenified hand dermatitis was 13%. Grape workers were more likely to report rashes in the last 12 months than were tomato workers or citrus workers. Grape workers were more likely to have contact dermatitis and lichenified hand dermatitis than were citrus or tomato workers. Increasing hours per week in agriculture, male sex, and not wearing gloves were associated with more lichenified hand dermatitis. We conclude that skin disease in agricultural workers may be causally associated with crop-specific exposures and lack of protective equipment.

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Agricultural employees may be at higher risk for occupational dermatitis than any major industrial group in the United States,[1] but few data exist on dermatitis prevalence or risk factors for skin disease.[2] Hired farm workers constitute a large and economically important segment of agricultural workers in the United States, numbering from 2.5 to 5 million.[2,3] Determinations of dermatitis prevalence and risk factors for skin disease are important for investigating "outbreaks" of disease in this population and for reducing disease incidence through identification of associated risk factors. Recognized risk factors for dermatitis in the farm-worker population include chemical exposures such as pesticides,[4-6] naturally occurring plant substances,[7-10] heat, sunlight, and humidity,[11,12] atopy, and infectious fungal and bacterial agents.[11]

The prevalence of dermatitis in general populations has been estimated in several large studies including Western Europe,[13] the United States,[14] and the Netherlands.[15] Dermatitis has been studied in Hispanics in the United States,[16] but few data exist concerning the prevalence of dermatitis in any agricultural populations, including predominantly Hispanic California farm workers. Outbreak investigations in agricultural workers,[5,6,17] and a pilot cross-sectional study of farm workers[18] indicate that dermatitis is a major health concern in this occupational group.

Occupational classification in California agricultural workers has been linked to presumptive etiology of der-

matitis: chemical-associated (non-plant) dermatitis has been associated with horticulture and crop services such as "fruit/tree/nut" workers, whereas groups such as forestry workers have been associated with plant-related dermatitis.[1]

This study was designed to measure the prevalence of dermatitis in the farm-worker population and to provide data on associated risk factors. To evaluate crop-specific dermatitis risks, we chose to focus on grape, citrus, and tomato workers in California's Central Valley region. Our a-priori hypothesis that dermatitis would be higher in grape workers was formed from a pilot study[18] in which the prevalence of reported rash in the last 12 months was higher in grape workers than in a control group of tomato workers. We chose citrus and tomato workers as control groups because they have different crop-associated exposure but similar ethnic and socioeconomic backgrounds.

Materials and Methods

This dermatitis study was carried out simultaneously with a study of respiratory disease and pulmonary function. Study methods have been previously described.[19] The study population consisted of grape, citrus, and tomato workers in four central California counties. A sample of cooperative growers provided access to farm workers from which the 759 subjects were drawn. Participation rates were 96% for the grape workers, 91% for citrus workers, and 92% for tomato workers. Work crews numbered from 16 to 41 persons; grape workers were selected from nine crews, tomato workers were drawn from 12 crews, and citrus workers were sampled from six crews. Subjects received $10 for their participation. Sampling consisted of a questionnaire and a "waist-up" skin examination. The questionnaire was developed to address work history, demographic variables, medical history, and skin problems. The questionnaire was translated into Spanish by bilingual employees familiar with the farm-worker population.

One physician (P.W.) performed all skin examinations using criteria developed for diagnosis of skin disease.[18]

Site Characteristics

Maximal temperatures were obtained from US Weather Service records at the airport closest to the field being sampled. Maximum temperature generally increased with later date, from 70° to 101° Fahrenheit.

Information on the most recent field application of pesticides to the fields in which the participating crews were working was provided by growers but was incomplete. Collection of data on individual worker exposure or area samples were not within the scope of this study. Elemental sulfur alone was used in two vineyards, which was applied every 10 days ("sulfur only" vineyards). In the other four grape work sites ("multiple pesticide"), the major reported applications were triadimefon (Bayleton), methamyl (Lannate), sulfur, and *Bacillus thuringiensis* (Dipel). Oil emulsifiers and gibberellins (Pro-Gibb, a growth regulator) also were applied around the time of the study. Dates of application were not available. Pesticides and growth promoters used in citrus fields were chlorpyrifos (Lorsban), formetanate (Carzol), methamyl (Lannate), manganese sulfate, urea, copper sulfate, zinc sulfate, and 2,4-D. Pesticides used on tomato fields included trifluralin (Treflan), napropamide (Deverol), pebulate (Tillam), glyphosphate (Roundup), sulfur, parathion, maneb (Dithane), ethephon (Ethrel), fenvalerate (Pydrin), dimethoate, and carbaryl (Sevin).

Data Analysis

The questionnaire outcomes of interest were a history of skin rash lasting 2 or more days in the last 12 months, the location and number of days the worker had the rash, whether or not the rash improved on days off of work, the number of lost work days due to these rashes, and whether health care was sought for these rashes. The variables of interest on physical examination were ocular abnormalities such as conjunctival dis-

charge, pustular eruption including miliaria, folliculitis, and nonfacial acne, contact dermatitis, lichenified hand dermatitis, paronychia, sun-related skin damage such as actinic keratosis, atopic conditions such as atopic dermatitis and keratosis pilaris, facial acne, and excoriation of unclear etiology.

Of these outcomes, the variables felt most likely to represent field exposures were contact dermatitis, lichenified hand dermatitis, and a reported history of a rash in the last 12 months lasting 2 or more days. Contact dermatitis was defined as an eczematous eruption with or without vesiculation with a distribution not suggesting atopic dermatitis or psoriasis. The case definition took into account uncertainty in the diagnosis by incorporating a four-category probability ranking based on the examiner's subjective impression; "definite, probable, possible, and not likely." Cases defined as "probable" or "definite" were combined for analysis, and cases classified as "possible" or "not likely" were also combined. Lichenified hand dermatitis was defined as a chronic, thickened, indurated, plaque of skin on the hands, notable on the dorsum, with accentuation of the skin folds, excluding callous skin.

Predictor variables tested in regression models included crop worked at the time of the interview (grapes, citrus, or tomato), the average months worked per year in agriculture (<8, ≥8), average hours per week worked in agriculture in the last month (<35, 35–44, 45–54, 55+), age (<25, 25–34, 35–44, 45+ years), gender, protective clothing worn "normally...during work" (yes/no), lifetime history of hay fever (yes/no), and job activity at the time of the survey.

Statistical analyses were performed using procedures available in the Statistical Analysis System (SAS) software library.[20] Associations were analyzed by cross-tabulation tables, followed by stepwise logistic regression. All predictor variables were initially explored as a first-order interaction or a "main effects" model. Second-order interactions were evaluated in all

models and removed when not significantly contributing to the model.

Job Activities and Pesticide Exposure

Job activities were defined for grape workers as: (1) turning canes—manually moving canes over a guide wire to expose underbranches to sunlight and promote aeration of the plants, (2) tipping—removal of fruits from the "tip" of the cane to promote branching and further growth, and (3) pulling leaves—removal of foliage from around fruits to increase sunlight and aeration. Citrus workers were manually picking fruit from trees (harvesting), and tomato workers were harvesting (manually), thinning bunches of tomato plants, or hoeing.

As a crude estimate of pesticide exposure, grape farms were classified into "sulfur only" (sulfur only applied in the fields) or "multiple pesticide" (a wide variety of pesticides used in the fields). The associations of vineyard pesticide use classification with dermatologic outcomes were tested for statistical significance by Fisher's exact test and χ^2 analysis.

Results

Male workers constituted the majority of participants in each crop (59% to 89%), and the highest percentage of females was found among grape workers (59%). Smoking status was similar between crops. Grape and citrus workers were more likely than tomato workers to live in a house or apartment in town and less likely to live on a farm or in a labor camp. The highest educational grade completed (median = 5th grade) did not vary by crop. Only 1% of subjects reported more than a high school level of education. Most subjects (747/759) classified themselves as Hispanic, and 98% completed the interview in Spanish.

Grape workers reported working somewhat fewer months per year in agriculture but more hours per week than did citrus workers. Conversely, grape workers reported working fewer hours per week but more months per year than tomato workers. However,

the median duration of employment in agriculture in years was similar between groups (8 to 11 years).

Almost all citrus workers were engaged in harvesting at the time of data collection. The most frequent tasks among grape workers were tipping and pulling (101/238), turning canes (86/238), harvesting (22/238), or vine tying (13/238). Most tomato workers reported harvesting (203/355), thinning bunches (36/355), or hoeing (68/355). One tomato worker was spraying pesticides, and eight were operating machinery.

The majority of subjects reported wearing long sleeves (91%) and wearing a hat at work. The reported use of some protective measures varied by crop and by gender. Gloves were worn by all citrus workers but by less than half the grape and tomato workers. Scarves and eye protection were worn by more grape workers than by citrus or tomato workers. Women reported using more skin protective behavior (sunscreen, long sleeves, gloves) than did men. Gloves were reported to be used by the majority of female subjects but by less than half of male participants, and more female subjects reported wearing goggles or glasses or a scarf at work.

In general, there were few major differences in nondermatologic medical diseases and symptoms when data were analyzed by crop.[19] However, grape workers were more likely to report a history of hay fever than were workers in the other crops (21% for grape workers versus 9% for both citrus and tomatoes) and eye irritation most days of the week at work (54% for grape, 18% for citrus, and 13% for tomato workers).

Reported Rash

Sixty-two percent of the subjects with contact dermatitis, and 3% of subjects with lichenified hand dermatitis on examination had indicated on questionnaire that they had a rash lasting more than 2 days in the last 12 months. The median duration of reported rashes was 6 days. Seventy of the 90 subjects with reported rash (78%) indicated that the rash improved on days off. Less than one fourth (19/90 = 21%) reported seeing a health care professional for their rash.

Rashes within the past 12 months lasting longer than 2 days were more frequently reported by grape workers than by citrus or tomato workers (Table 1). Among grape working crews

TABLE 1
Prevalences of Symptom and Physical Examination Findings by Crop

	Tomatoes n (%)*	Citrus n (%)*	Grapes n (%)*	Total n (%)*
Totals	355 (100)	166 (100)	238 (100)	759 (100)
Questionnaire				
Reported history of				
Rash ≥2 d in past 12 mo	22 (6.2)	18 (10.8)	50 (21.0)	90 (11.9)
Physical examination				
Pustular eruption	109 (30.7)	52 (31.3)	45 (18.9)	206 (27.1)
Facial acne	58 (16.3)	41 (24.7)	33 (13.9)	132 (17.4)
Lichenified hand dermatitis	42 (11.8)	7 (4.2)	54 (22.7)	103 (13.6)
Keratosis pilaris	45 (12.7)	18 (10.8)	37 (15.5)	100 (13.2)
Conjunctival erythema	50 (14.1)	7 (4.2)	19 (8.0)	76 (10.0)
Paronychia	43 (11.8)	1 (0.6)	20 (8.4)	64 (8.4)
Excoriation unclear etiology	1 (0.3)	30 (18.1)	31 (13.0)	62 (8.2)
Contact dermatitis	3 (0.8)	0 (0)	13 (5.5)	16 (2.0)
Other eczematous rash	2 (0.6)	0 (0)	2 (0.8)	4 (0.5)

* (%) are the percentage of subjects within each crop.

the prevalence of reported rash ranged from 9% to 54%. Among citrus and tomato workers the prevalence of reported rash did not differ significantly by site or crew. The prevalence of reported rash was not associated with interviewer or interviewer sex. The number of years in agriculture and average number of months per year in agriculture were not associated with reported rash.

Logistic regression controlling for age, sex, and a lifetime history of hay fever found crop to be a significant ($P < 0.05$) predictor of reported rash, with grape workers more likely than tomato workers (odds ratio [OR] = 2.8, 95% confidence interval [CI] = 1.6–4.9) or citrus workers (OR = 1.3, 95% CI = 0.7–2.4) to report a rash within the last 12 months (Table 2). Women were significantly ($P < 0.05$) more likely than men (OR = 3.1, 95% CI = 1.9–5.1) to report this outcome. Increased prevalence of reported rash was also associated with a reported history of hay fever (OR = 3.3, 95% CI = 1.9–5.7).

Physical Examination

On physical examination, the most frequently diagnosed conditions were pustular eruption, facial acne, lichenified hand dermatitis, and keratosis pilaris (Table 1). The overall prevalence of contact dermatitis was 2%.

The sites of contact dermatitis included arms, chest, head, hands, and back. Contact dermatitis was diagnosed more often in grape workers than among workers in the other crops. Among grape working crews, the prevalence of contact dermatitis ranged from 0% (in three crews) to 25% (5/20 in one crew) but was not related to ambient temperature.

Logistic regression analysis controlling for sex, age, and hay fever history found that grape workers were significantly more likely than were tomato workers to have contact dermatitis on examination (OR = 4.5, 95% CI = 1.2–17.0). No contact dermatitis was found in citrus workers. A lifetime history of hay fever was significantly ($P < .05$) associated with contact dermatitis (OR = 10.6, 95% CI = 3.3–43.5) (Table 2). Contact dermatitis was not associated with keratosis pilaris or job activity.

Lichenified hand dermatitis was also more prevalent in grape workers than in workers in the other two crops (Table 1). Among grape working crews, the prevalence of lichenified hand dermatitis ranged from 0% (in two crews) to 50% (10/20 in one crew) and was unrelated to ambient temperature. Logistic regression analysis controlling for age, sex, number of hours per week in agriculture, and wearing gloves found that lichenified hand

dermatitis was significantly more prevalent in grape workers than in tomato workers (OR = 4.4, 95% CI = 2.4–8.1) or citrus workers (OR = 4.1, 95% CI = 1.4–11.8) (Table 3). The prevalence was lower in women than in men (OR = 0.2, 95% CI = 0.1–0.4), was significantly associated ($P = .01$) with more reported hours per week in agriculture in a dose-response manner, and was increased in those not reporting regular use of gloves (OR = 2.3, 95% CI = 1.2–4.3) (Table 3). No association was found with job activity. Among grape workers, the prevalence of contact dermatitis was higher in "multiple pesticide" compared with "sulfur only" vineyards (7.45% vs 0.01%, $P = .01$). By contrast, lichenified hand dermatitis was more prevalent among "sulfur only" than "multiple pesticide" vineyards (34% vs 17%, $P < .01$).

Discussion

This study was designed to evaluate the prevalence of occupationally related skin disease in agricultural workers, to assess risk factors for disease, and to test the hypothesis that grape workers have more skin disease than do citrus or tomato workers. The labor-intensive nature of grape working,

TABLE 2
Estimates of Risk for Reported Rash and Contact Dermatitis

Predictor Variable	Reported Rash*		Contact Dermatitis on Examination	
	OR†	95% CI‡	OR	95% CI
Gender				
Females/males	3.1	1.9–5.1	1.4	0.5–4.4
Crop				
Grapes/tomatoes	2.8	1.6–4.9	4.5	1.2–17.0
Grapes/citrus	1.3	0.7–2.4	—§	
Lifetime hay fever history				
Yes/no	3.3	1.9–5.7	10.6	3.3–43.5

* Reported rash = report of rash lasting 2 or more d in the last 12 mo based on questionnaire response.
† OR = odds ratio logistic regression estimate simultaneously controlled for crop, gender, lifetime hay fever history, and age with 95% confidence levels.
‡ CI = confidence interval.
§ Not applicable. No cases of contact dermatitis in citrus workers.

TABLE 3
Estimates of Risk for Lichenified Hand Dermatitis

Predictor Variable	OR*	95% CI†
Gender		
Females/males	0.2	0.1–0.4
Crop		
Grapes/tomatoes	4.4	2.4–8.1
Grapes/citrus	4.1	1.4–11.8
Wear gloves		
No/yes	2.3	1.3–4.3
H worked/wk		
<35	1.0	Reference
35–44/<35	1.0	0.4–2.1
45–54/<35	1.4	0.6–3.0
55+/<35	3.1	1.3–7.0

* OR = odds ratio from logistic regression estimate with 95% confidence intervals simultaneously controlled for crop, gender, wearing gloves, h worked/wk, and age.
† CI = confidence interval.

the extensive foliar exposure entailed, and the possibility for exposures to crop-specific chemicals such as pesticides indicate that grape workers may be at increased risk for allergic and irritant dermatologic disease such as contact dermatitis and lichenified hand dermatitis.[18]

A limitation of this study is that exposure assessment was restricted to information on work and activities provided by questionnaire. Although the questionnaire provided important information essential for analysis, associations may not have been detected because of the limitations of the questionnaire as an exposure assessment tool. This is particularly important in attempting to assess risks associated with pesticides, because employees may not be aware of their workplace exposures such as pesticide application amounts, dates of application, or chemical types.

The observed prevalence of skin conditions in these study subjects may have been biased by several factors. Selection bias because of the "healthy worker effect" may have resulted in underestimation of disease prevalence, inasmuch as more severely affected workers are less likely to be working and therefore will not be available for study. It is unlikely that regular workers would be so significantly affected from dermatitis that they would miss work, but new hires might develop severe skin reactions and be selected out of this occupation. Another possible source of selection bias arises from the method of choosing participants as a sample of cooperating growers, as those growers not willing to participate may be subjecting their workers to greater risks. We cannot specifically address the extent of this bias, but we are not aware of any such selection process and do not believe it would result in differences in dermatitis prevalence among groups.

Information bias is a potential problem in this study, because it was not possible to totally blind interviewers and the examiner to the research

hypotheses. Efforts to minimize this bias included use of a single examiner and standardized training of the examiner and interviewers.

Reporting bias is also a concern: grape workers may have been more motivated to report dermatologic symptoms than were tomato or citrus workers. A possible manifestation of this bias arose when we noted that grape workers were more likely to report a history of hay fever than were other workers. Simultaneous logistic regression analysis indicated, however, that this and other reporting differences (including age and gender) did not account for the increased reporting of rash by grape workers. In addition, the majority of nonspecific health complaints were not elevated in grape workers, suggesting that systematic reporting biases in grape workers were not causing increased reporting of skin rashes.

Grape workers were more likely than were tomato workers to be women, live in a house or apartment in town, and work longer for the same employer. Most of these variables were unrelated to outcomes, but age and sex effects were controlled by inclusion in logistic regression models.

Local environmental factors such as season, weather, and soil conditions may also confound the relationship between crop worked and dermatologic outcomes. High skin temperatures may be a risk factor for irritant dermatitis,[12] and seasonal variation in skin reactivity to patch testing of irritants has been described.[21] Some grape workers were studied later in the summer than were the tomato or citrus workers, were working in somewhat hotter environments, and were working in a different geographic area, but no obvious relationship was seen between ambient temperature and dermatitis prevalence. We were unable to fully randomize the time of crop testing because of practical constraints and budgetary limitations, and we could not randomize crop by geographical location because of the region-specific nature of crop produc-

tion in the Central Valley. However, the timing of our visits was unlikely to explain the reported prevalence of skin rash in the previous 12 months, which was also higher among the grape workers.

Causative Agents

Many factors may contribute to dermatitis in farm workers, including type of crops cultivated, specific job activity, use of personal protective measures, field and home sanitation, environmental conditions (eg, heat and humidity), personal hygiene, allergic history (including atopy), and ethnicity.[22] Several pesticides have been shown to cause irritant and allergic contact dermatitis.[4,23,24] Epidemiologic investigations of the role of pesticides in causing dermatitis in California have produced mixed results, with some studies finding a causal role[5,6] but others finding no effect.[25,26] Differences in methodology for determining the environmental persistence of applied pesticides may partly account for the different conclusions drawn from later studies. Nonpesticide crop exposures are also a cause of dermatitis. Known causal agents include psoralens, citral and limonene from citrus fruit,[10] tomato juice,[9,10] grape leaves, stems, and resins from grape skin.[7]

The relationship between pesticide exposure and skin decrease could not be addressed definitively in this study as we have incomplete information on the most recent pesticide application for these fields, and a detailed personal exposure evaluation of each participant was beyond the scope of this study. However, the association of contact dermatitis with "multiple pesticide" grape farms suggests that pesticide exposure may be causally related to contact dermatitis in grape workers and may partially explain the variations in prevalence of skin disease and symptoms noted between different grape working crews.

Rash Prevalence

Our observed prevalence of contact dermatitis in farm workers (2%) was similar to dermatitis prevalence in the Hispanic Health and Nutrition Examination Survey (0.8% with "eczema" and 0.2% with inflammation),[16] the National Health Survey (1.4% with contact dermatitis),[14] the Lantinga study (7.1% with eczema of hands and forearms) which was a community based survey of older Europeans,[15] and our earlier study of California farm workers (2% with contact dermatitis).[18]

The reported prevalence of rash in the last 12 months (12%) contrasts with 54% seen in our pilot study.[18] Within grape workers, the 21% prevalence in our study contrasts with 62% in the earlier study, and within tomato workers our prevalence of 6% contrasts with 21% in the earlier study. Our pilot study was carried out later in the growing season than was the present study, job activities were different between the pilot study and this study (83% of the grape workers in that study were harvesting, compared with 9% in the present study), and more women were sampled in the pilot study (54% women compared with 22% in the current study). Such differences either in the population sampled or in the time of sampling may have influenced the reporting of rashes within the last year. Prospective surveillance of farm workers will be necessary to ascertain "true" rates of skin disease.

The physical examination was designed to measure dermatitis prevalence and the questionnaire primarily for cumulative dermatitis incidence. The questionnaire had only limited sensitivity for dermatologic conditions (62% for workers with contact dermatitis and 3% for those with lichenified hand dermatitis). The questionnaire may be missing contact dermatitis of very acute onset (less than 2 days old), and could better estimate prevalence by focusing on current disease. The low sensitivity for licheni-

fied hand dermatitis may be due to translational, cultural, or conceptual differences in what constitutes a "rash." Skin conditions such as lichenification are chronic processes that are often less symptomatic than acute contact dermatitis and may therefore be overlooked.

Caution must be used in interpreting the association of "multiple pesticide" farms with dermatitis, as the associations were not controlled for age, sex, or socioeconomic status. Lichenified hand dermatitis and contact dermatitis may both result from irritant or allergic mechanisms.[11] Sulfur has been shown to cause irritant dermatitis,[23] suggesting that exposed workers would be at risk for irritant dermatitis. On the other hand, certain nonsulfur pesticides (particularly fungicides) have been demonstrated to cause allergic as well as irritant dermatitis,[11] and workers in "multiple pesticide" vineyards may be more at risk for allergic dermatitis. We were unable to separate allergic from irritant dermatitis cases in this study because the physical examination alone was insufficient evidence for such a determination.

Our finding that persons with a history of hay fever had a higher prevalence of both reported rashes and contact dermatitis suggests these workers may be more susceptible to adverse effects of occupational exposures. Hay fever is associated with atopy, which is suspected of predisposing persons to irritant contact dermatitis.[11,27] Atopy should be documented with skin testing in future studies investigating its association with occupational skin disease.

Conclusions

This study provides support for the hypothesis that grape working was causally related to skin disease. Although there were no measurements of exposures such as foliar contact in this study, grape working is a labor-intensive occupation requiring extensive physical contact with plants and plant products. The study finding sug-

gest that crop-specific exposures and behavioral variables including the use of gloves when in the field and the number of hours per week worked are important determinants of these outcomes.

Acknowledgments

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Unnecessary Grief

Far hence amid an isle of wondrous beauty,
Crouching over a grave an ancient sorrowful mother,
Once a queen, now lean and tatter'd seated on the ground,
Her old white hair drooping dishevel'd round her shoulders,
At her feet fallen an unused royal harp,
Long silent, she too long silent, mourning her shrouded hope and heir,
Of all the earth her heart most full of sorrow now because most full of love.
Yet a word ancient mother,
You need crouch there no longer on the cold ground with forehead between
    your knees,
O you need not sit there veil'd in your old white hair so dishevel'd,
For know you the one you mourn is not in that grave,
It was an illusion, the son you love was not really dead,
The Lord is not dead, he is risen again young and strong in another country,
Even while you wept there by your fallen harp by the grave,
What you wept for was translated, pass'd from the grave,
The winds favor'd and the sea sail'd it,
An now with rosy and new blood,
Moves to-day in a new country.

—From "Old Ireland" W. Whitman in
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