

Dermatitis in Ecuadorean farm workers

DONALD C. COLE^{1,3}, FERNANDO CARPIO², JIM JULIAN M. MATH³ AND NINFA LÉON²

¹Environmental Health Program, McMaster University ²Fundacion NUESTRA, Quito, Ecuador

³Occupational Health Program, McMaster University, Canada

Using a cross-sectional survey of potato farm workers in northern Ecuador, we examined the relationship between pesticide exposure and skin disorders. From a farm population census, all pesticide applicators and 1/2 of exposed field workers were selected. Controls were age-matched from urban occupations. Individual exposure measures included overall years and current hours working with pesticides. Farm-level measures included numbers of applications over the last 6 months and an application practices score (range 0-4). Each participant underwent a clinical skin examination, with patch tests to maneb on a sample of dermatitis cases. Exposure-related increases in conjunctivitis (7% of applicators, 0% in other groups), dermatitis (68% of exposed and 55% of applicators versus 31% of controls, $p < 0.001$) and pigmentation disorders (25% of exposed and applicators vs 10% controls, $p = 0.06$) were found. Among dermatitis cases ($n = 117$), 5% were positive to maneb on patch testing. In logistic regression analysis, significant predictors ($p < 0.1$) of dermatitis included years using fungicides (OR = 1.12 per year) and poor application practices (OR = 1.42 per score unit). Agricultural fungicide application in high-exposure situations can contribute to dermatitis prevalence among farm populations.

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The widespread use of agricultural pesticides in the developing world, with minimal precautions to reduce exposure, has been an ongoing concern for health personnel with the focus gradually broadening from the more obvious acute poisonings to include a range of chronic effects. Nevertheless, in the chapter on epidemiological data in a review carried out for the World Health Organization (1), the sole reference to skin effects cites Adams' text (2). The latter reviews the predominantly case literature on contact dermatitis, allergic sensitization and photoallergic reactions to a wide range of pesticides. A significant literature also exists on occupational dermatoses in farmers (3) and farm workers (4). Among the physical, chemical and infectious agents which can potentially produce skin disease among farmers and farm workers, pesticides are important. Reviewing reports of pesticide poisonings treated by physicians in Japan from 1968-1970, Matsushita and co-workers (5) found 39% had skin lesions in general and 26% ($n = 216$) had dermatitis. All but 3 of the cases were farmers applying a range of fungicides, organophosphates and organochlorines. Case reports and animal work have demonstrated

the allergenicity of the ethylene bisdithiocarbamate fungicides such as maneb (6, 7) and the organophosphate insecticides (8, 9). Although surveys have been conducted of farmers, particularly dairy farmers in Scandinavia, few prevalence studies have been carried out in developing countries, where direct contact with pesticides is likely to be more frequent and more intense due to the climatic conditions and limited use of preventive practices (1).

An opportunity to examine skin effects of regular agricultural use of pesticides came about because of the interest of the Rockefeller Foundation and the International Agricultural Research Centers in assessing the sustainability of pesticide use among agricultural producers. Work in the Philippines was followed by a project with the International Potato Centre in Ecuador, which combined research on agricultural production, environmental contamination and human health impacts. The human health project included a poisoning surveillance system, an exposure monitoring study and a cross-sectional study among the farm population. Data on neurotoxic effects and poisonings have been reported elsewhere (10). This paper reports

on the skin outcomes across exposure groups in the cross-sectional study.

Materials and Methods

Setting

Ecuador is classified as having a medium level of human development (11). The canton of Montufar, the study site, is in the northern province of Carchi on the central sierra, near the Columbian border. It has a dispersed rural population, farming potatoes, grains and dairy cattle around a small town, San Gabriel. Literacy in 1982 was estimated at 86% with an average schooling of approximately grade 5 (12). Prior to the initiation of the project, Carchi had the highest provincial rates of pesticide poisonings reported to the Ministry of Health, with 22 cases per 100,000 population (13). Exposures were generally thought to be high, due to limited use of personal protective equipment while handling more toxic products (14). Since most farmers and their workers are not covered by the equivalent of Workers' Compensation, no specific figures are available for occupational dermatoses.

The agricultural economics research team had randomly selected collaborating potato farmers from the municipal land registry within 2 watersheds. Among those actively farming, they obtained collaborators who provided monthly production information. It became clear that potato production is a risky, high cost venture, requiring many more labor days and purchased inputs than other field crops (10). The collaborating farmers used 38 different fungicides and 28 different insecticides, applying to each plot, on average, more than 7 applications with 2.46 products in each application, almost all with backpack sprayers due to the hilly terrain. 43 different active ingredients (AI) were used but 3 compounds dominated: the dithiocarbamate fungicide maneb made up more than 80% of all fungicide AI applied; the carbamate carbofuran and the organophosphate methamidophos, both restricted products in the US and Canada, made up 47% and 43% of all insecticide AI applied, respectively.

Populations

The health team conducted a census of all those capable of doing farm work, including family members and various kinds of contract labour. The farm population included those not doing direct farm work though still potentially exposed in other locations (consumers), those performing work in the fields (exposed) and those applying pesticides in addition to other tasks (applicators).

The health team decided to include all applicators, approximately $\frac{1}{2}$ of the exposed, and all consumers in the sampling frame, thereby oversampling the extremes of likely exposure to achieve greater contrast within the farm population. Changes between the initial sampling frame and the final group of participants arose because of farmers who died (2) or moved (1), contract labourers who were absent for more than 1 month, or family members who were reluctant to participate in the extensive testing required (both the latter 2 groups accounted for less than 20%). Replacements for contract labourers had to have worked on the farm for more than 4 months and have carried out similar tasks. Controls, with a similar distribution of age, sex and years of formal education, were obtained from the local non-farm population through community groups and the municipal government. 1 control was selected for every 2 exposed or applicator farm members, using frequency matching. Control occupations included housewives, students, labourers, skilled workers, small-business persons and professionals. Incentives to participation included the equivalent of $\frac{1}{2}$ the average daily local wage as well as a snack during the assessment (overall duration of approximately 4 h, including all tests carried out). All participants provided informed consent prior to testing and were provided with immediate feedback on positive clinical examination findings, with referrals by the field physician as appropriate.

Exposures

Individual exposure measures were obtained by an interviewer-administered questionnaire. A record of prior pesticide poisonings by year was made. For all groups, work exposure assessments included the numbers of times using solvents and pesticides. Among the exposed and applicator farm population, information on past pesticide use (years) by name and current use (h) during the last month were obtained from the participant. Pilot testing of the questionnaire in a similar rural area resulted in modifications of wording and order.

At the farm level, the agricultural research team provided information on recent pesticide applications in a representative 6-month period for dithiocarbamate fungicides and carbamate and organophosphorus insecticides. The health team conducted structured farm observations and interviewed the farmers regarding pesticide use practices. Most practices likely to increase pesticide exposure were common across farms: mixing pesticides with hands and a stick (36 out of 40 farms), using no effective personal protective equipment other than rubber boots (38/40) and disposing of

pesticides in an unsafe manner (35/40). Several application variables showed differences across farms: frequent leakage from the backpack sprayer (28/40) (coded "no"=0 or "yes"=1), length of usual workday when applying pesticides (range 6 to 11 h, recoded to "less than 8 h"=0, "8 h"=1, "greater than 8 h"=2), and presence of other workers in the fields during applications (18/40) (coded "no"=0, "yes"=1). Using these items, a farm application practices index was created (range 0 to 4), with higher values denoting increased potential exposures for the same pesticide use.

Skin outcomes

A dermatological reporting form was developed in consultation with Ecuadorian dermatologists to assure inclusion of local terms for skin conditions. The field physician first conducted a complete visual examination of the skin, followed by a history of physician-diagnosed skin and allergic disorders. Past history reports were infrequent, likely due to the limited health care to which the population has access, particularly that of skin specialists, and so will not be described further.

If physical examination indicated the presence of a dermatitis and the participant reported aggravation with contact with the fungicide maneb, they

underwent patch testing ($n=17$). Maneb alone was chosen because of the fungicide use patterns in the population and the reported cross-reactivity with the next most commonly used fungicide, zineb, also a dithiocarbamate (9). Despite literature on organophosphate and other pesticide patch tests (16), such products were not commercially available. The Trolab[®] 1% in petrolatum preparation of maneb was employed, using Finn Chambers with readings at 30 min, 2 days and 4 days. Interpretation codes were those recommended by the International Contact Dermatitis Research Group (17).

Covariates

All participants answered a separate series of demographic questions. Age and sex have been shown to affect the occurrence of contact dermatitis (18).

Analysis

Each section of the questionnaire and results of the dermatological examination were entered into separate FOXPRO datafiles by the Ecuadorian team. The Canadian research team conducted an audit of the entire record for 10% of the records. For those sections with deficiencies, all records were reviewed and corrected by comparison to the

Table 1. Exposure group characteristics and comparisons

Variable	Exposure Group					Group effect <i>p</i> -value
	(0) control (<i>n</i> =72)	(1) consumers (<i>n</i> =23)	(2) exposed (<i>n</i> =28)	(3) applicators (<i>n</i> =123)	ALL (<i>n</i> =246)	
<i>Demographic</i>						
Sex						
male	79%	0%	14%	96%	73%	<0.001
female	21%	100%	86%	4%	27%	
Age (years)	$\bar{x}$: 36.40 sd: 18.06	37.04 18.25	34.74 17.16	37.99 16.28	37.06 17.03	0.81
Education (years)	$\bar{x}$: 6.31 sd: 3.41	6.48 3.44	5.71 2.73	5.79 3.02	6.00 3.14	0.57
<i>Relevant past health history</i>						
No. skin conditions unlikely related to pesticides:						
none	93%	74%	82%	84%	85%	0.097
1 or more	7%	26%	18%	16%	15%	
<i>Other relevant exposure</i>						
solvent use (years)	$\bar{x}$: 1.22 sd: 4.89	0.44 2.09	0.25 1.00	0.65 3.39	0.75 3.64	0.58
<i>Pesticide exposure related</i>						
Number of pesticide poisonings:						
none	97%	87%	93%	72%	83%	<0.001
1 or more	3%	13%	7%	28%	17%	
Hemoglobin-adjusted red cell cholinesterase: (IU/min/ml/gm)	$\bar{x}$: 29.75 sd: 3.63	25.58 6.31	25.25 5.95	26.56 4.06	27.25 4.72	<0.001

Table 2. Pesticide exposure summary by farm exposure group

Variable	Exposure Group		
	(1) consumers (n=23)	(2) exposed (n=29)	(3) applicators (n=123)
<i>General pesticide use:</i>			
past (cumulative years)			
$\bar{x}$:	0.00	10.26	15.96
sd:	0.00	8.44	10.73
recent (#applications in last 6 months)			
$\bar{x}$:	27.50	23.60	24.49
sd:	13.75	15.60	13.25
application practices score (range 0-4)			
$\bar{x}$:	N/A	2.29	2.51
sd:		1.15	1.03
current (hours during last month)			
$\bar{x}$:	4.52	42.71	110.50
sd:	20.01	37.45	59.55
<i>Dithiocarbamate use</i>			
past (years)			
$\bar{x}$:	0.00	10.46	15.14
sd:	0.00	8.34	9.68
recent (#app)			
$\bar{x}$:	12.32	11.08	12.18
sd:	5.74	6.87	6.33
current (hours)			
$\bar{x}$:	0.17	1.29	24.59
sd:	0.83	3.09	28.06
<i>Insecticide use</i>			
past (years)			
$\bar{x}$:	0.00	10.89	16.59
sd:	0.00	8.43	10.77
recent (#app)			
$\bar{x}$:	15.18	12.52	12.31
sd:	9.89	10.23	9.27
current (hours)			
$\bar{x}$:	0.17	4.00	29.38
sd:	0.83	7.46	30.76

N/A: not applicable to this exposure group.

hard-copy questionnaires or data-sheets. Data distributions were visualized using the MINITAB analytic software (release 9.2). Such visualization facilitated a number of data analysis steps: identification of outliers, for further error checking; collapse of categories within variables; and aggregation across variables. Given the wide variety of dermatological diagnoses made (>50), the latter 2 were particularly important. Flat files were then created for further analysis using MINITAB (release 9.2) and SAS for Windows (version 6.10). The χ^2 test was applied to differences in proportions of skin findings across exposure groups. Dermatitis was a frequent and important enough finding to permit logistic regression modelling of exposure and demographic predictors across successively more pesticide exposed populations. To create these populations exposure groups were consolidated, starting with the largest of all participants and ending with the just the applicators. Only those variables whose co-efficients were found to be significant at the $p < 0.1$ level are presented, with odds ratios calculated for occurrence

of dermatitis based on levels of the variable in question.

Results

The first section of Table 1 sets out values for key demographic variables across the 4 exposure groups. A sex-based division of labour is apparent in contrasting the farm consumers (all women), with the pesticide applicators (predominantly men). Considerable success was achieved in achieving similar levels of age and education across the exposure groups (both non-significant group effects). Reports of a past history of skin conditions not likely related to pesticide exposure (e.g., psoriasis, juvenile acne) were slightly higher among the farm population, particularly the consumers. Reported exposures to a variety of non-pesticide skin irritants were infrequent in this population. Solvents were the most common but no significant differences were observed across the exposure groups.

The extent of past and present pesticide exposure can be gauged from the measures in the last

section of Table 1 and all sections of Table 2. The number of reported pesticide poisonings (Table 1) is higher in the farm groups, with the highest proportion among applicators, although the consumers also indicate an important proportion of poisonings. The latter may indicate movement out of direct work with pesticides due to susceptibility to poisoning, exposure due to home storage or use of other pesticides or confusion concerning the cause of a similar clinical syndrome. In Table 2, an increasing gradient is apparent for cumulative past years and current hours of work with pesticides from the consumers through those exposed via non-application work to those predominantly engaged in application. Hours of work with pesticides over the last month (current variable in Table 2) showed the largest gradient in exposure among the farm groups. The recent variable (Table 2) represents the number of pesticide applications occurring on the farm in the last 6 months, with similar values of about 2 applications per month each of dithiocarbamate fungicides and various insecticides. Little variation across farm groups exists because recent use is not a measure of each individual's work with pesticides. Similarly, mean farm application practices scores were not significantly different between exposed and applicator farm groups.

Skin findings on physical examination showed differences across exposure groups (Table 3). Conjunctivitis ($n=9$) was found only among applicators, consistent with the irritant effects of pesticides either airborne or transferred to the eyes by rubbing with the hands. Dermatitis ($n=119$, 48%) was most common among the exposed and applicators, in areas likely to be exposed to pesticides such as the hands or on the back underneath the sprayer. The vast majority of cases (>80%) had chronic hand dermatitis, with findings of roughness, fissuring and scaling with or without lichenification. Most farm members indicated that fungicide use aggravated their dermatitis, perhaps ac-

counting for the higher rates found in those generally exposed during farm labour compared to direct applicators. Patch testing carried out on 17 of those with chronic hand dermatitis revealed 6 with positive (weak or strong) reactions to maneb, 5 with unclear reactions and 5 negative. Among the growths found ($n=4$), lipomas on the back were the most common. A variety of pigment disorders ($n=49$) were observed more frequently in the exposed and applicators, including cloasma, vitiligo and leukoderma. Finally, other skin conditions such as corns, fungal infections (potentially due to the humid environment), acne, miliaria and a variety of other rashes were commonly encountered ($n=138$), with the highest prevalence among the applicators.

Dermatitis was chosen as the skin outcome for modelling purposes because of the extent of the inter-group differences in prevalence and the degree of its relationship to pesticide use in exploratory analyses. Table 4 presents logistic regression results for dermatitis (present or absent) for various combinations of the exposure groups. The number of years using fungicides, but not current use, was consistently strong as a predictor of dermatitis for all farm groups (odds ratio=1.12, or a 12% increase in risk for each year of use). For the exposed with a mean of 10.5 years of use, this would mean odds of having dermatitis of 2.3. For the applicators with a mean of 15 years of use of fungicides, their mean odds would be 2.8. There was no independent effect of insecticide usage. Application practices also contributed to the risk for the farm exposed and applicator groups (odds ratio=1.42–1.49, or a 40–50% increase in risk per unit increase in the score). For the exposed, their presence in the fields during application could increase their contact with pesticides via drift as bystanders or their direct contact with sprayed foliage, while for the applicators more extensive and/or longer duration of skin contact with pesticides may occur directly. Over $1/2$ the exposed and ap-

Table 3. Skin findings encountered by exposure group

	Exposure groups				Group effect <i>p</i> -value
	(0) control ($n=72$) (%)	(1) consumers ($n=232$) (%)	(2) exposed ($n=282$) (%)	(3) applicators ($n=1232$) (%)	
Skin disorder ^a					
conjunctivitis	0	0	0	7	0.025
dermatitis	31	43	68	55	0.001
growths	1	0	7	1	0.100
pigmentation disorder	10	17	25	25	0.060
other	60	30	43	62	0.017
any skin disorders	79	65	89	89	0.021

^a Multiple disorders could be found in one individual.

Table 4. Predictors of dermatitis using logistic regression by population: estimated coefficients, (standard error) and odds ratio (OR)

Predictors	Population (exposure groups)			
	all (0+1+2+3) (n=246)	all farm (1+2+3) (n=166)	work exposed (2+3) (n=144)	applicators (3) (n=119)
intercept	0.082 (0.137)	-0.574 (0.277)	-1.705 (0.620)	-2.398 (0.715)
group (2 versus 0)	0.837 (0.226) OR=2.31	N/A	N/A	N/A
group (2 versus 3)	N/A	0.592 (0.254) OR=1.81	0.602 (0.259) OR=1.88	N/A
fungicide use (years)	N/A	0.096 (0.020) OR=1.10	0.113 (0.024) OR=1.12	0.110 (0.025) OR=1.12
application practice score (0-4 range)	N/A	NS	0.350 (0.183) OR=1.42	0.402 (0.204) OR=1.49
% concordant	84	75	76	77
% discordant	16	25	24	23

N/A: not applicable to this analysis. NS: not significant at $p < 0.1$.

plicators had application practices scores of 3 or more, resulting in odds of having dermatitis of 2.3 or more. These relationships were independent of age and sex. No first order interactions were statistically significant ($p < 0.10$).

Discussion

The highland Ecuadorians in this survey were found to have a considerable number of skin disorders on physical examination. Among these findings, dermatitis was the most important, affecting almost $\frac{1}{2}$ of the population, the vast majority of these having hand dermatitis. In contrast, reported prevalences from population surveys in developed countries have found rates of 32/1000 for atopic and contact dermatitis in the USA (19) and 12% for hand eczema in southern Sweden (20). The high prevalence of hand dermatitis may be due to the humid, cool conditions of the area, coupled with more rudimentary living and working conditions. However, higher rates of skin problems in farm populations are consistent with higher annual workers' compensation incidence rates for occupational skin disease, particularly dermatitis, in the agricultural sector in other jurisdictions (21, 22). Similarly, lichenified hand dermatitis occurred in 13.6% and contact dermatitis in 2.0% of Hispanic grape, tomato and citrus workers examined in California (4). Among the same workers, conjunctival erythema was noted in 10%, similar to findings of conjunctivitis in our Ecuadorian applicators. Little has been published on

prevalence of pigmentation disorders in agricultural populations, something which our findings suggest should be further investigated. Chloasma has been associated with excess exposure to ultraviolet radiation, a distinct possibility for agricultural workers outside much of the day at high altitudes.

In terms of causes of dermatitis, O'Malley et al. (21) attributed almost half to exposure to plants, trees and vegetation and only about 20% to chemical exposures. We did not collect information on plant or animal exposures but exposure to cold and physical abrasion from hand agricultural tools was common among the exposed and applicators. As well, relatively complete pesticide exposure histories were obtained. Rates of positive patch tests to maneb were considerably higher than that observed in Italian patients including agricultural workers (16), where positive reactions were rare, potentially due to lower rates of use of maneb. As well, application practices and general use of protective equipment likely result in greater exposure than most developed country situations. For example, work in the Philippines has shown that spillage occurred during mounting the backpack sprayer and poor maintenance of the sprayers resulted in leakage on the back and hands (23).

When exposure to pesticides is ongoing, acute (hours to days), sub-acute (weeks) and chronic (months to years) reactions may be superimposed. The dose-response relationship based on years using fungicides among the exposed and applicators indicates an independent contribution from

fungicide exposure that points to a more important role for chronic than acute exposure. A relationship with fungicide years is consistent with the known allergenicity of these compounds. Yet some findings within the farm population appear anomalous. Why should exposed non-applicators have a higher prevalence of dermatitis than applicators? Is this partially a sex effect, with more women among the exposed workers who are also exposed to household cleansers and hand washing of clothes? Or is selection into field work and out of application occurring, a trend not able to be captured in this cross-sectional study?

Cross-sectional studies have a number of inherent limitations (24). Those who participate are survivors who have not succumbed to a lethal or debilitating pesticide poisoning, though they may change tasks as a result of such a poisoning (e.g., farm work [exposed] to domestic work [consumers]). Non-family farm members have stayed working with pesticides and are hence less likely to show the adverse effects of pesticides than those who have left for health reasons, including incapacitating dermatitis. Use of family members from a stable agricultural community (in addition to high-turnover contract labourers) may partially respond to this problem of underestimating the true effect of pesticide exposures. On the other hand, individuals vary over time, making one observation a potentially poor reflection of their ongoing exposure or health status, generating imprecision which will also lead to underestimates of the effects of exposure. All these factors limit the conclusiveness of evidence from cross-sectional studies such as ours. Ideally, a rural population cohort should be followed for periods of time to limit selection biases and permit better documentation of temporal relationships between pesticide exposures and adverse skin outcomes. Focusing on high exposure situations in the developing world or immigrant groups in developed countries, such as the work of Gamsky et al. (4), is most useful.

Nevertheless, our findings point to fungicides as important contributors to the current prevalence of dermatitis in this Ecuadorian farm population. More attention needs to be devoted to skin problems of farm members in developing countries, along with research across different climate and fungicide use examples. Our findings point to the need for training in application practices to reduce exposure and, in the longer term, reduction of fungicide use through integrated pest management strategies.

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Address:

Donald C. Cole
HSC 2C1, McMaster University
1200 Main St. W., Hamilton
Ontario, Canada L8N 3Z5

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