PI-178

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Farm Family Exposure to Glyphosate[1]

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Introduction

This publication describes the Farm Family Exposure Study, conducted in 2000 to determine farm-family exposure to the commonly applied herbicide, glyphosate. The purpose of the study was to quantify real-world pesticide exposures immediately before, during, and after a pesticide application and to identify significant factors that influence exposure. The study was funded through a research contract with the University of Minnesota and sponsored by Bayer, Dow, DuPont, FMC, Monsanto, Syngenta, and the American Chemistry Council.

Methods

Farm families were recruited by randomly drawing licensed pesticide applicators from state listings in South Carolina and Minnesota. Criteria for participation in the study included the following:

- The farmer, spouse, and at least one child -- 4 to 18 years of age -- had to live on the farm.
- The farmer had to farm at least 10 acres within 1 mile of the family residence.
- The farmer must plan to apply one of or a combination of the following: glyphosate, 2,4-D, or chlorpyrifos. (Only glyphosate results are described in this publication).
- Family members had to be willing to collect all urine voids for five consecutive days -- the day before the pesticide application, the day of the application, and for three days after the application.
- The farmer and spouse had to be willing to fill out pre- and post-study questionnaires that detailed family activities for the week before the study and the week of the study.
- The farmer and spouse had to agree to have their on-study pesticide application observed by trained field staff.

Participating families were given a cash incentive of $300 and reimbursed for the pesticide used during the on-study application to a maximum of $1,000. Laboratory analyses were used to determine urinary glyphosate concentrations.

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Results

Table 1 details characteristics of participating farmers and their spouses based on their questionnaire responses. Of the 48 farmers, 10 reported never wearing gloves when working with pesticides, 14 had applied glyphosate within a week before their scheduled on-study application, and the same number had made another application within three days of their on-study application. Most of the farmers reported having tractors with enclosed cabs.

On the day of the on-study glyphosate application, a trained observer was present at each farm, documenting practices and conditions that can influence exposure potential (Table 2). Of the 48 farmers, 14 were not wearing gloves during the application. According to the product label for the glyphosate used in this study, gloves were not required to be worn. However, use of rubber gloves when handling pesticides reduces dermal contact and absorption. All the farmers used tractors and boom sprayers, and most applied the Roundup Ultra® formulation over glyphosate-tolerant crops early in the growing season. Skin contact with glyphosate was observed for 15 of the farmers and approximately 15 percent of farmers were observed to have had spills during mixing or application. Thirteen repaired their equipment at some time during the application.

Urine concentrations of glyphosate for farmers ranged from less than 1 ppb to 233 ppb (Table 3). Some farmers did not have detectable glyphosate in their urine samples despite applications in excess of 100 acres. Overall, 29 farmers participating in the study had detectable values on the application day, declining to 13 farmers by the third day following the glyphosate application. The average concentration for farmers was 3.2 ppb on the application day, and the concentration declined thereafter. Findings differed between South Carolina and Minnesota. On the application day, 87 percent of the South Carolina farmers had detectable values, compared with 36 percent of the Minnesota farmers. Mean values were 7.9 ppb in South Carolina and 1.4 ppb in Minnesota (Table 4).

Of the farmers spouses, two had detectable concentrations on the day of application. No spouse participated in the glyphosate application. Nine of 78 children who provided samples had a detectable value on the day of application. Of these nine children, all but one were reported by their parents to have been present for or assisted with mixing or application activities.

Among the farmers who participated in the study, urinary concentrations were lower for those who were observed to wear rubber gloves when mixing and loading glyphosate (Table 4). The concentration for those wearing rubber gloves was 1.5 ppb, versus 9.7 ppb for other farmers. Use of rubber gloves was much more common in Minnesota than in South Carolina. The number of acres treated was not related with urinary glyphosate concentration, but there was a trend between concentration and the number of times farmers mixed and loaded the concentrated herbicide. Other factors positively associated with urinary concentration were using an open cab tractor, observed skin contact with the glyphosate concentrate, and repairing equipment during the application.

Use of rubber gloves was a major influence on glyphosate urinary concentrations (Table 5). For farmers who did not wear rubber gloves, the number of acres treated, the number of mixing operations, observed spills, and repairing equipment were associated with large differences in urinary concentrations.

According to the EPA, the lowest no-effect level from glyphosate toxicology studies is considered to be 175 ppm. The reference dose, an estimate of the daily oral exposure to the human population, including children, that is not likely to cause harmful effects during a lifetime, is 2 ppm per day. The urinary glyphosate concentrations presented in the study were exponentially lower than these values in all instances.

In all of these pesticide-handling activities, rubber glove use minimized urinary concentrations of glyphosate. Most pesticide product labels specify some type of protective gloves during handling activities. The study provides emphasis for the importance of protective glove use.

Several limitations should be considered when interpreting the results of the study:

- There was only one application per family, so the results would not reflect the variation in exposure over a season or over years of applications.
- All applications were made using a tractor and boom sprayer, so the results may not be representative of other applications methods.
- Participation in the study may have influenced application practices because of being observed with the study's field staff.

Additional Information

Acquavella, J.et.al. 2004. Glyphosate Biomonitoring for Farmer-Applicators and Their Families: Results from the Farm Family Exposure Study. Environ. Health Perspect:112:321-326. http://www.farmfamilyexposure.org/index.html (accessed April, 2009).

Fishel, F.M. 2006. Glove Selection for Working with Pesticides. EDIS Publication PI-120, http://edis.ifas.ufl.edu/document_pi157 (accessed April, 2009). Department of Agronomy, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

U.S. EPA. 1993. Re-registration Eligibility Decision (RED) Glyphosate. EPA-738-R-93-014. Washington, D.C.: U.S. Environmental Protection Agency, Office of Pesticide Programs and Toxic Substances.

Table 1. Characteristics reported by farmers and spouses.

Characteristic	Number of farmers	Number of spouses
Total in study	48	48
Minnesota	25	25
South Carolina	23	23
Average age (years)	45.0	42.2
Average years lived on farm	40.8	26.4
Average years applied pesticides	23.9	---
Additional job	--	--
Yes	20	35
No	28	13
Currently smoke cigarettes	--	--
Yes	7	7
No	40	41
No answer	1	
Schooling	--	--
High school or less	19	20
Vocational school	12	6
Some college	4	7
College or graduate degree	12	13
Other	1	2
No answer		
Applied glyphosate in last seven days before study	--	
Yes	14	
No	34	
Applied glyphosate within three days after on-study application	--	
Yes	14	
No	34	
Enclosed cab	--	
Yes	29	
No	19	
Glove changes	--	
Do not wear	10	
Change 1 – 4 times per season	13	
Change when worn out	12	
Change each time	5	
Change once a month	5	
Other	3	
Spouse mixed any pesticides in week prior to study		--
Yes		2
No		46

Table 2. Field observers' characterization of farmers on the day of application.

Observation	Number of farmers
Rubber glove use when mixing/loading	--
Yes	34
No	14
Acres treated	--
10 – 44	16
45 – 124	16
125 – 439	16
Number of loads	--
1 – 2	12
3	15
4 – 6	12
7 – 12	9
Tractor with closed cab	--
Yes	29
No	19
Pesticide spills during mixing	--
Yes	7
No	41
Spills during application	--
Yes	8
No	40
Skin contact with pesticide	--
Yes	15
No	33
Repaired equipment during application	--
Yes	13
No	35

Table 3. Average urinary glyphosate concentration values for study participants.

Study participant	Number of samples	Concentration (ppb)	Range (ppb)
Farmer – applicator	--	--	--
Preapplication	47	7	< 1 – 15
Application day	48	29	< 1 – 233
Postapplication day 1	48	23	< 1 – 126
Postapplication day 2	48	16	< 1 – 81
Postapplication day 3	48	13	< 1 - 68
Spouses	--	--	--
Preapplication	47	1	< 1 – 3
Application day	48	2	< 1 – 2
Postapplication day 1	48	0	All < 1
Postapplication day 2	48	1	< 1 – 1
Postapplication day 3	48	1	< 1 - 1
Children	--	--	--
Preapplication	76	5	< 1 – 17
Application day	78	9	< 1 – 29
Postapplication day 1	78	7	< 1 – 24
Postapplication day 2	79	5	< 1 – 12
Postapplication day 3	75	4	< 1 - 6

Table 4. Average urinary glyphosate concentration values on the day of application according to field observers' observations.

Observation	Number of farmers	Concentration (ppb)	Range (ppb)
State	--	--	--
Minnesota	25	1.4	< 1 – 66
South Carolina	23	7.9	< 1 - 233
Rubber glove use when mixing	--	--	--
No	14	9.7	< 1 – 233
Yes	34	1.5	< 1 - 66
Acres treated	--	--	--
10 – 44	16	2.9	< 1 – 34
45 – 124	16	2.9	< 1 – 233
125 – 439	16	3.8	< 1 – 101
Number of loads	--	--	-
1 – 2	12	1.2	< 1 – 19
3	15	2.9	< 1 – 233
4 – 6	12	3.8	< 1 – 34
7 – 12	9	10.7	< 1 – 101
Closed cab	--	--	--
No	19	6.5	< 1 – 233
Yes	29	2.0	< 1 – 101
Spills during mixing	--	--	--
No	41	2.7	< 1 – 101
Yes	7	7.3	< 1 – 233
Spills during application	--	--	--
No	40	2.5	< 1 – 66
Yes	8	9.2	< 1 – 233
Skin contact with pesticide	--	--	--
No	33	2.0	< 1 – 51
Yes	15	9.0	< 1 – 233
Repair equipment during application	--	--	--
No	35	2.3	< 1 – 66
Yes	13	7.2	< 1 – 233

Table 5. Average urinary glyphosate concentration values on the day of application according to use of rubber gloves and field observers' observations.

Observation	Use of rubber gloves			
	Yes		No	
	Number of farmers	Concentration (ppb)	Number of farmers	Concentration (ppb)
State	--	--	--	--
Minnesota	24	1.4	1	---
South Carolina	10	4.5	13	12.2
Acres treated	--	--	--	--
10 – 44	10	3.4	6	2.1
45 – 124	11	0.9	5	33.7
125 – 439	13	2.5	3	25.1
Number of loads	--	--	--	--
1 – 2	8	0.8	4	2.5
3	11	1.8	4	10.6
4 – 6	9	2.6	3	11.4
7 – 12	6	5.1	3	45.8
Closed cab	--	--	--	--
No	12	4.7	7	11.2
Yes	22	1.2	7	8.4
Spills during mixing	--	--	--	--
No	28	1.7	13	7.6
Yes	6	4.1	1	232.7
Spills during application	--	--	--	--
No	28	1.7	12	6.1
Yes	6	3.6	2	153.6
Skin contact with pesticide	--	--	--	--
No	27	1.5	6	6.8
Yes	7	6.2	8	12.6
Repair equipment during application	--	--	--	--
No	27	1.9	8	4.6
Yes	7	2.4	6	26.0