Chapter Five

POTENTIAL MISUSE OR OVERUSE OF PESTICIDES

It is difficult to evaluate whether pesticides were used properly, given the nature of the survey data. This is because the data primarily describe frequency of use by form of pesticide. Without data on color and smell, in general, it is not possible to link any given form to a specific active ingredient. An additional difficulty is the accuracy of self-reported data. Thus, we can report only what respondents told us; we often cannot determine whether a potential misuse is simply a case of misidentification or actual misuse.

In spite of such difficulties, in this chapter we highlight those identifiable cases in which pesticide use is questionable (either in terms of potential overuse or misuse). Most of these results are based only on those pesticides that were specifically named by respondents. Although such an analysis does not lend itself to statistical generalizations for the population, it does serve to indicate areas possibly deserving additional study.

POSSIBLE MISUSE OR OVERUSE

Personal Pesticides

Permethrin. Permethrin is a synthetic pyrethroid that acts as a contact repellent against mosquitoes, biting flies, and crawling arthropods such as ticks and chigger mites. Permethrin binds so strongly to fabric that treated uniforms will continue to provide protection after several washings. The recommended use of permethrin 0.5 percent was for bed netting and uniforms (except the uniform cap, underwear, and T-shirts). Directions for use state to spray the clothing from a distance of six to eight inches away, for at least 30 seconds on each side and allow to dry for two to four hours according to ambient humidity and to reapply after six weeks and its sixth laundering.[1] However, the literature

[1]Permethrin Arthropod Repellent NSN 6840-01-278-1336 label on each six-ounce can. Approved label by U.S. EPA April 1990. Also in AFPMB (1996).

indicates that when used in conventional doses, permethrin is safe even when applied to the skin in small doses (Cecchine et al. forthcoming).

In Chapter Three, we assumed that the pesticides were appropriately used—that sprays used on the body were DEET. However, almost 31 percent of the personnel (n = 143,394) indicated using a military-issue spray. If these military-issue sprays were instead all classified as permethrin, since the only spray available from the military supply system was permethrin-based, then we would estimate that (1) 1.5 percent of the population would have sprayed permethrin on their bodies (n = 7,024), and (2) another 20 percent would have sprayed it on some combination of body and uniform (n = 94,923).

Among the respondents who provided pesticide names, we observed five individuals (3 Army, 1, Marine Corps, and 1 Air Force, representing 1,600 individuals in the population) who named permethrin and said they used it on their bodies, and another 10 who said they used it on their body and uniform. Frequency of use varied from every other day to four times a day over the 30-day period surveyed. While the interpretation of "military issue" as meaning from the military supply system is too strict, these two estimates provide bounds on the likely bodily application of permethrin: from less than 1 percent to about 20 percent of the population. Based on the survey results of Gambel et al. (1998), we expect that the actual number is closer to the lower bound.[2]

d-Phenothrin. d-phenothrin, like permethrin, is a synthetic pyrethroid insecticide. The literature indicates that when used in conventional doses, d-phenothrin, like permethrin, is safe even when applied to the skin in small doses (Cecchine et al, forthcoming). Directions for use on aircraft are to spray for ten seconds per 1,000 cubic feet in a sweeping motion and to stop ventilation for at least three minutes after spraying. Directions for use indoors (in buildings, vans, ships, or tents) are to spray for ten seconds per 1,000 cubic feet in a sweeping motion three feet away from surfaces and to close the treated area for at least 30 minutes after spraying and to ventilate before re-entry.[3] Instructions on the label say that d-phenothrin should not be used on skin or clothing. However, among the respondents who provided pesticide names, three individuals indicated that they used d-phenothrin as a personal pesticide (representing 1,292 personnel in the population); two of the three indicated they used it on their uniforms, and one on uniform and body. Frequency of use ranged from 60 times in 30 days to four times in 30 days.

---

[2]Gambel et al. found that more than 90 percent of Army soldiers did not treat their uniforms with permethrin before deployment, and more than 75 percent did not treat them during deployment.

[3]Insecticide, aerosol, d-phenothrin, 2 percent NSN 6840-01-412-4634 label on each 12-ounce can. Approved label by U.S. EPA 1982. Also in AFPMB (1996).

Lindane. Lindane, an organochloride pesticide, was used as a field pesticide in the delousing of prisoners of war. However, many U.S. soldiers were also issued small containers of lindane for personal use. Directions for use indicate that personnel should use no more than one can of two ounces per week for up to two weeks for head and body lice.[4] In the survey data, 11 people (representing 4,072 people in the total population) reported using powders with colors and smells consistent with lindane (see Table C.3). Of these, five people indicated that they used the powder from one to three times each day, every day, for the 30-day period surveyed; another three indicated that they used it daily for one to three weeks; and three used it fewer than five times in a month.

Field-Use Pesticides for Personal Use

Parathion. Parathion, an organophosphate, is a highly toxic insecticide.[5] Parathion may be purchased and used only by certified applicators. It is used to control boll weevils and many biting or sucking insect pests of agricultural crops, primarily cotton. It kills insects by contact, or through ingestion and respiration. One respondent reported using parathion in a spray form on his uniform every day; however, we suspect that the respondent likely meant permethrin.

DDT. Four respondents, representing 1,367 people in the population, reported using DDT. Two reported it in spray form and two in liquid in frequencies that ranged from eight to 20 times in 30 days. Although DDT was held in war reserve stocks by the DoD until July 1992, no DDT was issued during the Gulf War. It is most likely that the respondents mistakenly identified DEET as DDT.

Other Pesticide Use

Flea Collars. Table 3.9 shows that approximately 3 percent of Army and Marine Corps/Navy personnel and about 1 percent of Air Force personnel used animal flea and tick collars. Flea and tick collars contain organophosphates, carbamates, pyrethroids, and organochloride pesticides that may have adverse dermal or systemic effects. Their safety has not been tested for human use.[6] Almost 50 percent of the respondents who wore the collars wore them for the entire 30-day period they were questioned about. The majority of them wore the collars over their clothes or shoes.

---

[4]Insecticide lindane powder 1 percent NSN 6840-00-242-4217 label on each two-ounce can. Approved label by U.S. EPA 1986.

[5]EXTOXNET *Pesticide Information Profiles (PIPs)* at http://ace.orst.edu/cgi-bin/mfs/01/pips/methylpa.htm?8#mfs.

[6]AFPMB (1996).

No-Pest Strips. Table 3.18 shows that about 7 percent of the in-theater Gulf War personnel used or observed the use of No-Pest strips. No-Pest strip insecticide has dichlorvos, an organophosphate, as the active ingredient (Cecchine et al., forthcoming). Between 5 and 8 percent of the personnel who reported using No-Pest strips indicated that they were hung in densities higher than one per 1,000 cubic feet, the maximum recommended by the manufacturer.[7]

MULTIPLE PESTICIDE USE

We found that personnel who reported a high frequency of use with one pesticide form would have been more likely to use (or report) high frequencies for multiple forms and thus might be exposed to a "cocktail" of pesticides. For both personal-use and field-use pesticides, we found that the number of people reporting multiple uses over the 95th percentile is greater than what would be expected by chance alone. This conclusion continues to hold even when the services are considered separately—personnel reporting high frequency of use or observed use of one form are more likely to report high use of another form.

We also found that those who report frequent use of personal pesticides tend to report frequent use of field pesticides. Seasonality and geography are likely to explain some or all of these associations. However, they could also be at least partially explained if some respondents had a tendency to either experience or report high use in general.

We examined the 12 people who had three or four high frequencies of use (above the 95th percentile) of personal pesticides and found them demographically similar in only one respect: eleven of the 12 were either retired or civilian. Otherwise, they were from all the services, of a variety of ranks and races and shared other demographic characteristics. Of the 12, 11 frequently used personal sprays, nine frequently used personal liquids, nine used lotions, four powders, and three flea or tick collars.

We also examined the 25 people who had three or four high frequencies of use of field pesticides. The distribution across services was as expected, with the Air Force having the fewest personnel (four), followed by the Marine Corps/Navy (eight), and then the Army with the largest number (13). Of the 25 respondents, 20 reported high frequency of use of field powders, 14 of aerosols, 12 of "other" spraying, 11 of field liquids, and ten of pellets, granules, and crystals. Within this group, active duty, reserve, retired, and civilian personnel were all roughly

[7]Insect Guard, a product with the identical active ingredient as No-Pest strips and from the same manufacturer, Loveland Industries, is currently being sold in neighborhood drugstores. Although these may have been hung in densities greater than recommended, they may also have been hung in the open air, which would mitigate or eliminate any excessively high pesticide concentrations.

equally represented. Other demographics within the Marine Corps/Navy personnel reflected the larger respondent population. The same is true for Air Force personnel, except that three of the four were senior enlisted.

The Army personnel demographics, on the other hand, were somewhat unusual. Of the 13 Army personnel, ten were African-American and seven were senior enlisted. (Not all the senior enlisted were African-American, however.) It is unlikely that this could happen by chance.[8] The unusually high number of senior enlisted personnel for both the Army and the Air Force supports our initial hypothesis that senior personnel would have additional knowledge and information about the use of field pesticides. The high number of Army African-American personnel is consistent with the results in Tables 4.8 and 4.10, although we do not have a satisfactory explanation for it.

We also examined the effect of removing the 12 personal-use and 25 field-use "high use" personnel from the models for Tables 4.7 through 4.10. We found that removing them has no practical effect on the results.

PB PILLS

We estimate from the survey data that slightly more than half of the in-theater Army and Marine Corps/Navy personnel took PB pills, as shown in Table 5.1, whereas only about one-quarter of the Air Force took them. Of those who took PB pills, our data indicate that on average the personnel in all services took about one pill per day.

Although the Air Force is clearly different in terms of the fraction of personnel who took PB pills, among those who took them there is no statistical difference

Table 5.1

Estimated Fraction of the In-Theater Gulf War Population Who Took PB Pills

Use of PB Pills	Total	Army	Marines/ Navy	Air Force
Percent of population (s.e.)	48(2)	52(2)	51(2)	23(2)
Estimated number of personnel (out of 469,047 personnel on the ground in theater)	223,501	158,889	48,599	16,012

[8]If one of five personnel are African-American (roughly the fraction of the 2,005 respondents), then the chance that out of 13 randomly chosen personnel ten or more are African-American is about one in a million. In this same vein, the senior enlisted results are less striking, although still statistically significant. Roughly 30 percent of respondents are senior enlisted; the chance that seven or more are senior enlisted out of 13 randomly chosen personnel is about one in 50.

between the services for the average number of pills taken in a 30-day period. As Table 5.2 shows, however, among the personnel who took PB pills, the quantity taken varied significantly. Median use was 20 pills in a 30-day period—or about two per day for ten days—across all the services. The maximum reported usage was *nine* pills a day, or 224 in a month.

Most of the personnel who used PB pills reported taking three or fewer per day for fewer than 30 days out of the month they reported, but some respondents reported taking a large number of pills for most of the month. As Table 5.3 shows, 21 respondents, or about 1 percent of the sample, indicated that they had taken four or more pills per day. At the most extreme, one or more individuals reported taking four, five, seven, and eight pills a day for 30 days, which means they took the pills at that level of dosage for the entire month we asked them about.

Table 5.2

Average Frequency of Use and Percentiles for Frequency of Use Among Those Who Took PB Pills

	Total GW Population (n = 223,501)		Army (n=158,889)		Marines/Navy (n = 48,599)		Air Force (n = 16,012)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average (s.e.)[a]	26(1)	1.7(<1)	26(2)	1.7(<1)	27(2)	1.7(<1)	28(2)	1.9(<1)
Percentile								
50	20	2	20	2	20	1	20	2
75	31	2	31	2	31	2	42	3
95	84	3	63	3	84	3	93	3
100	114	9	217	9	224	8	93	6

NOTE: The columns labeled "Times/day" indicate the number of times per day *for the days used.*

[a]"s.e." stands for "standard error," a commonly used statistical measure of the variability of the average.

Table 5.3

Daily Frequency of Use and Number of Days Used in the Month Surveyed Among Those Who Took Three or More PB Pills per Day

Army		Marine Corps		Air Force		Navy	
Per Day	Days Taken	Per Day	Days Taken	Per Day	Days Taken	Per Day	Days Taken
4	6	4	2	4	3	None with four or more per day	
4	14	4	5	4	21		
5	31	4	7	5	2		
6	2	4	15	6	3		
7	31	4	30				
8	7	4	31				
9	21	5	15				
		5	30				
		6	7				
		8	28				

In a logistic regression model,[9] we find that the odds of taking PB pills in the winter are twice the odds of taking them in the summer ($p = 0.001$)—a result likely attributable to the events during that point in the war and not to the season—and the odds of males taking PB pills are three times those of females ($p = 0.001$).[10] Also, the odds of African-American personnel taking PB pills are twice those of Caucasians ($p = <0.001$), and personnel in the desert had twice the odds of taking PB pills of personnel in tent cities ($p = 0.002$), who in turn had twice the odds of personnel in buildings ($p = 0.009$).

Those who took the pills, however, took 66 percent more pills in the summer ($p = 0.003$), females took almost 140 percent more ($p = 0.01$), and senior enlisted took about 30 percent more ($p = 0.02$). Thus, although fewer female personnel and personnel in-theater during the summer took PB pills, those that did took more than their peers.

PB PILLS AND PESTICIDES

We found that the number of PB pills taken in a month is statistically significant and positively associated with the total number of applications of personal-use pesticides, even after accounting for known differences in pesticide and PB pill usage. The number of PB pills taken in a month has a small, positive correlation with the monthly frequency of application of personal-use liquids ($r = 0.16$ with $p = 0.06$) and lotions ($r = 0.15$ with $p = 0.04$) individually. Correlations for other personal-use pesticides were insignificant, although with the exception of sprays, this may have been due to insufficient power from too few observations.[11]

To put this in more concrete terms, we estimated the fraction of the population who exceeded certain frequencies of use for PB pills and personal pesticides together. We derived these frequencies from the percentiles of the survey data. As Table 5.4 shows, we estimate that approximately 3,000 personnel took 56 or more PB pills in a month and at the same time applied personal-use pesticides 132 times or more. This averages out to two PB pills per day and four applications of personal-use pesticides. Similarly, we estimate that about 17,000

---

[9] See Appendix C for a discussion of the methodology.

[10] PB pills were most commonly taken during late January and February as a defense against a chemical warfare attack. Respondents, however, indicated taking PB pills as early as August 1990 and as late as July 1991. There are two explanations for this: (1) recall bias, with respondents misremembering details about the month they were supposed to be recalling, and (2) the possibility that some personnel took pills outside of the specific Gulf War period. We cannot tell whether one or both of these possibilities are true from the survey data.

[11] Sprays and flea collars had insignificant positive correlations; powders and "other" had negative correlations.

Table 5.4

Estimated Number in the Population Exceeding the Frequency per Month Both for Taking PB Pills and for Using Personal Pesticides

	Percentile							
	80th		85th		90th		95th	
	PB	Pesticide	PB	Pesticide	PB	Pesticide	PB	Pesticide
Times/mo	15	60	28	84	31	95	56	132
Estimated no. in population exceeding both	30,549		17,331		9,391		3,100	

personnel averaged about one PB pill per day and almost three applications of personal-use pesticides.

None of the field-use pesticides had significant monthly frequency of use correlations with monthly PB pill use and the directionality (signs) were mixed. Pellets and "other sprays" were negative, and the rest had positive (insignificant) correlation. However, field-use liquids had the largest correlation ($r = 0.31$, $p = 0.11$) and was consistent with personal-use liquids.

Frequency of use of personal sprays and lotions was found to be statistically significant in a multivariate regression of the number of PB pills, even after controlling for the effects of other important demographic covariates. We found that individuals who take more PB pills tend to have a greater frequency of use of personal pesticides, particularly sprays and lotions. This relationship may be a result of location, in which personnel in areas subject to pests were also more likely to be concerned about soman attacks.[12]

Figure 5.1 demonstrates the association between frequency of use of personal pesticides and PB pills. The bar shows the percentage of the population who used personal pesticides with a certain frequency. So, for example, about 6 percent of the population applied personal pesticides 120 times or more in a month.[13] To the right is the average frequency of use of PB pills for personnel within each group. For example, the 6 percent who used personal-use pesticides more than 120 times a month took an average of 19 PB pills in a month. Although the association is relatively modest, the effect of even modest combinations of pesticides and PB pills is not fully understood.

---

[12]Since the association between the regular use of field pesticides and PB pills was not statistically significant, we are inclined to discount recall bias as an explanation for the observed association.

[13]DEET was the most commonly used personal pesticide (technically, it is a repellent, not a pesticide). DEET has minimal AChE inhibitory potency. However, since the data are not detailed enough to allow us to determine exactly what each individual used, we can only aggregate all personal pesticide use.

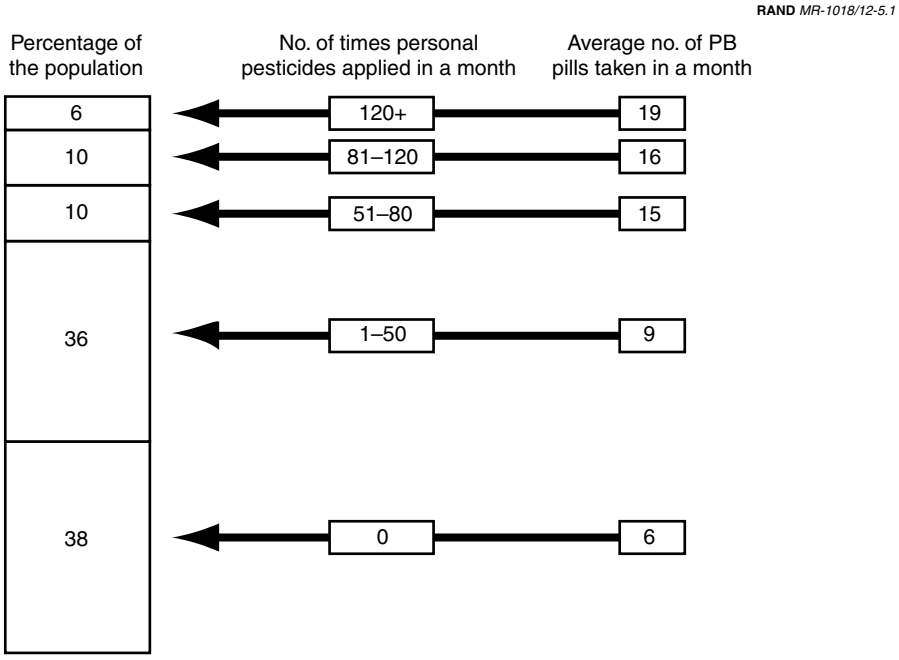

Figure 5.1—Comparison of Frequency of Use of Personal Pesticides to Average PB Pill Use

CONCLUSIONS

Evaluating misuse, multiple use, and overuse with these data is difficult at best because, even when the respondent can name a pesticide, conclusions are still inextricably confounded with recall bias and accuracy issues. For example, the cases we found of possible misuse and overuse can be explained either as true cases of misuse and overuse if one is willing to takes the responses literally. However, the examples of possible misuse of field pesticides are as likely or more likely to be examples of incorrect identification or reporting than misuse. The one clear example of misuse is with flea or tick collars, where there is little question that the respondents correctly identified and reported the pesticide product.

Similarly, it is difficult to find conclusive evidence of overuse of multiple pesticides. First, we can generally identify pesticide products only by form and not by active ingredient. Calculating frequency of use by form is a poor measure in which various active ingredients are unavoidably combined in unknown ways. Thus, we cannot define an objective measure of "overuse" linked to a specific

active ingredient. Second, even when we use a basic empirical approach, such as distribution percentiles, it is not necessarily true that people exceeding the 95th percentile actually overused a pesticide. It is only true that they used the pesticide form more frequently in relation to their peers. Third, the data show a correlation between high use of personal and field pesticides, which may be indicative of a seasonal effect, a reporting bias, or some combination of these two and other unknown factors. This makes it difficult to definitively identify those who may have actually used multiple pesticides often and those who simply tended to report higher frequencies of use than their peers.

However, we do find a positive association between the frequency of use of personal sprays and lotions and PB pills. Although the association is relatively modest (roughly, an additional daily application of a spray or lotion is associated with taking two additional PB pills in the 30-day period), the effect of even modest combinations of pesticides and PB pills is not fully understood. If pesticides and PB pills interact over time, as Golomb (1999) suggests, then this result suggests that further study is warranted.

Gambel et al. (1998), in surveys of deployed Army soldiers, found that information about personal protective measures (PPMs) used to prevent arthropod-related diseases and nuisance bites is not incorporated into commonly used soldier manuals or references and is not routinely trained or tested. They further found that 25 percent of soldiers felt that their commanders did not emphasize the use of insect repellents at all and another 26 percent felt that they emphasized it "some but not enough." Given that limited formal training is provided to Army, Air Force, Marine Corps, and Navy personnel in the use of PPMs,[14] it should not be surprising that individuals varied in their application of PPMs—some failed to use and some tended to overapply in the absence of proper guidance.

The difficulty in teasing these effects out of the survey data should not be taken as evidence that they do not exist, however. In this chapter we have highlighted examples of questionable pesticide use. It seems reasonable to expect that individuals who used one pesticide with a high frequency would also be predisposed to use others similarly. It also seems reasonable that people in environments with large numbers of pests, such as in the Persian Gulf, would be tempted to use whatever means was available to remove the pests, including

---

[14]For example, neither the *CB Combat Handbook Training Manual* (1989), the *Marine Battle Skills Training-Essential Subject Handbook* (1989), nor the *U.S. Army Soldier's Manual of Common Tasks: Skill Level 1* (1990) discusses personal protective measures. The U.S. Air Force has subsequently published *Manual 10/100, Airman's Manual* (1999), which does contain some information about PPMs.

using products in ways that were not recommended. Indeed, the use of flea collars is a clear example of this. Although we do not find clear evidence of widespread misuse of other pesticides—the timing and nature of this survey make finding such results difficult—it still may have occurred. We may have simply been unable to detect it almost a decade after the fact.