SUMMARY

Veterans of Operation Desert Shield/Desert Storm (ODS/DS) have reported an array of health complaints since the war. These complaints are often attributed to the veterans' deployment to the Persian Gulf, and the reported ailments have been popularly labeled *Gulf War illness*. Whether veterans are experiencing higher-than-expected rates of either known or unknown illnesses has not yet been determined. However, by 1997 the Veterans Administration (VA) had recorded approximately 15,000 veterans with undiagnosed symptoms, commonly including fatigue, muscle and joint pains, headaches, memory loss, skin rash, diarrhea, and sleep disturbances.[1]

Symptoms similar to some of those reported by Gulf War veterans may result from overexposure to various pesticides, but little is known about the use (or misuse) of pesticides during ODS/DS, particularly pesticide use by the average service member. In an effort to gather additional information, RAND was commissioned by the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses to survey veterans about the pesticides they personally used and other pesticides they used or observed being used in the field. The purpose of the survey was to augment available information about the extent of pesticide use by the troops, the level of multiple pesticide use, and the duration and frequency of use.

WHY SURVEY?

To date, a conclusive cause of illnesses among Gulf War veterans has not been found. We do know, however, that overexposure to various pesticides can cause symptoms similar to some reported by Gulf War veterans. Overexposure to pesticides, the use of pyridostigmine bromide (PB) pills (given to personnel in ODS/DS as a pretreatment to protect primarily against the nerve agent so-

[1] http://www.va.gov/health/environ/faq.htm.

man), and perhaps a combination of both pesticides and PB pills are among the possibilities still under investigation.

Before this survey the only available data on pesticides used in ODS/DS were (1) individual interviews conducted by the Office of the Special Assistant for Gulf War Illnesses (OSAGWI) with preventive medicine personnel, (2) logistics information quantifying the amount of military-issue pesticides ordered from the theater of operations, and (3) limited information from various epidemiological studies that have been conducted. However, the logistics information does not account for pesticides acquired outside the military supply system, and it does not provide any information about how the pesticides were used. The preventive medicine interviews, on the other hand, provide some information on field-use pesticides, but they provide little information about how personal pesticides were used by the average service member, and the results are not easily generalized to the entire Gulf War population.

Our survey results complement the other data collection efforts by the Department of Defense, such as interviews with military preventive medicine personnel and entomologists. Designed as one part of a larger research effort, this survey provides information only about pesticide use; it was *not* designed to investigate whether such use is related to health outcomes or symptoms.

WHO WAS SURVEYED AND WHAT INFORMATION WAS COLLECTED?

We conducted a telephone survey of 2,005 veterans from May to October 1999. They were randomly selected to be statistically representative of the Gulf War population. We drew the survey participants from Army, Air Force, Marine Corps, and Navy personnel who served *on the ground*[2] in the Kuwaiti theater of operations (KTO) between August 1, 1990, and July 31, 1991. Our population consisted of

- All Army and Marine Corps personnel located in Saudi Arabia, Kuwait, and Bahrain;
- All Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and
- Navy personnel in units that were identified as being ashore in Saudi Arabia, Kuwait, and Bahrain.[3]

---

[2]Personnel who were located at sea or who only flew over the area were ineligible to participate in the survey.

[3]The Coast Guard was included with the Navy. There were 848 Coast Guard personnel in the Gulf War database and through random sampling we selected five to be interviewed.

The Department of Defense has estimated that 697,000 personnel participated in ODS/DS. After removing those who were not eligible for the survey, we estimate that 469,047 personnel were actually on the ground in-theater during the one-year period of interest.

We designed the survey to elicit information about veterans' personal use of pesticides and those they observed others use. We solicited specific information about the identification and frequency of use of many possible pesticides, including common personal-use pesticides, unusual personal-use pesticides such as pet flea collars, and various common and rare field-use pesticides (such as aerial spraying). The pesticide information was elicited in the context of the veterans' living, working, and eating conditions for one randomly chosen month that each respondent was in theater.

Considering that this survey was fielded years after the end of the Gulf War, there was little expectation that the respondents would be able to recall the names of all the products used, especially those used in the field. In fact, Gambel et al. (1998) indicate that Army soldiers deployed in Kuwait, Haiti, and Bosnia had difficulty identifying military-issue personal-use pesticides during their deployment. Therefore, we employed a strategy in which the respondents focused on the forms of the pesticides. The forms included were lotions, sprays, powders, liquids, flea collars, small solids (specifically, pellets, crystals, and granules), and "other." For each form that a respondent indicated using, the pesticide name was first solicited—either its active ingredient or its trade name. If the name could not be recalled, a description was then solicited in terms of its color and smell.

We also randomly selected a subset of respondents who agreed to be reinterviewed with selected questions from the original survey to assess the reliability of their answers. We administered the second "recall bias" survey after about six weeks, during which time respondents were generally expected to have forgotten how they answered the first survey. In this way, we were able to examine if and how their answers changed over time.

WHAT DID WE FIND OUT?

We found that the majority of respondents were not able to recall specific pesticide details (such as name, color, or smell). As we expected, this difficulty was exacerbated for field-use pesticides that the respondents may have observed but usually did not apply themselves. The result is that we generally could not identify the active ingredients in pesticides from the survey responses. Thus, most of our tabulations and analyses were limited to identifying the form of the pesticide (such as spray, liquid, etc.), which respondents were able to recall relatively well.

We also found that the number of types of pesticides used or observed increased 13 percent from the initial survey to the recall bias survey. This difference occurred primarily among respondents who had given less thought to their Gulf War experiences in the intervening years. We also found that reports on frequency of use increased slightly in the recall bias survey. A "worst case" interpretation of this result is that the incidence of pesticide reporting, as we describe below, may slightly underestimate the actual use during ODS/DS, although the mix of pesticides reported in the main survey does not appear to be misestimated.

We examined recall in other ways, such as by education, by self-reported current health, and by whether respondents had thought much about pests and pesticides in the Gulf before the interview. The health question was a simple self-assessment, rating health as excellent, very good, good, fair, or poor. It is interesting to note that we found no significant variation in reports of pesticide use by health status, and no evidence of a dose-response type of relationship. Of course, this could be due to a number of factors, including small sample sizes, differences between two variants of the question, and other methodological reasons.

Basic Tabulations of Use

Personal-Use Pesticides. Personal pesticides are those obtained and used by individual service members, primarily for their personal comfort, either on their bodies, on their uniforms, or in their personal living spaces. Table S.1 lists our estimates of the percentage of the population using each form of pesticide and the median frequency of use per month (among those who reported using the pesticide form). We estimate that more than one-third of the population did

Table S.1

Use of Personal Pesticides by Form

Form	Percentage (No.) of Population Using Form	Median Frequency of Use per Month[a]
Spray	44 (207,414)	30
Lotion	26 (120,460)	20
Liquid	23 (105,425)	30
Powder	7 (33,790)	16
Flea collar	3 (13,291)	26
"Other"	2 (7,440)	12
None	38 (177,300)	—

[a]Among those who used the pesticide form.

not use any personal pesticides. Sprays were the most frequently used form of pesticide, followed by lotions and liquids.

Enough information was available on three personal-use pesticide active ingredients to allow us to impute the extent and frequency of their use. Table S.2 gives our imputed results, based on an assumption that the pesticides were appropriately used. ("Appropriately used" means that we assumed that sprays used on the body were DEET-based and not permethrin.) We found that one-half of the population used DEET, and those who used it did so with a median frequency of 30 times a month. Permethrin and sulfur were used less extensively and less frequently.[4]

Field-Use Pesticides. Field pesticides were generally those used in larger living, working, and exterior spaces. They may have been available to and applied by the respondent, and they may also have been pesticides that the respondent observed being applied. Table S.3 gives the basic results for field pesticides. Additional details about use of personal and field pesticides, including breakouts by service, can be found in Chapter Three.

Multiple Use of Pesticides. Figure S.1 shows the distribution of the number of personal pesticide forms used in theater. The figure shows, as previously mentioned, that more than one-third of personnel did not use any personal pesticides. Slightly over half of the population used one or two forms, generally a spray or a spray with either a liquid or a lotion (see Table S.1). The figure shows that very few personnel used more than two personal pesticide forms in any month.

Table S.2

Use of Personal Pesticides by Imputed Active Ingredient

Ingredient	Percentage (No.) of Population Using Ingredient	Median Frequency of Use per Month[a]
DEET	50 (235,962)	30
Permethrin	6 (30,032)	20
Sulfur	3 (15,437)	15

NOTE: Imputation assumed that pesticides were appropriately used, that is, that sprays used on the body were DEET.

[a]Among those who used the active ingredient.

[4]Permethrin-based sprays were the only sprays available from the military supply system. However, we found that a majority of personnel used commercial sprays, hence the finding of a large number of DEET-based sprays. The data are consistent with information about the military supply system: For those sprays we could identify positively, 77 percent of permethrin sprays were reported as "military issue;" 66 percent of DEET sprays were not military issue.

Table S.3

Use of Field Pesticides by Form

Form	Percentage (No.) of Population Using Form	Median Frequency of Use per Month[a]
Aerosols	28 (133,329)	30
Other sprays	20 (92,083)	4
Powders	13 (62,150)	16
Pellets, crystals, or granules.	12 (54,548)	30
No-Pest strips	7 (30,530)	(b)
Liquids	4 (18,242)	21
"Other"	3 (12,872)	30
None	51 (239,214)	—

[a]Among those who used the pesticide form.

[b]These data recorded the number of No-Pest strips per 100 square feet. Please see Table 3.18 for details.

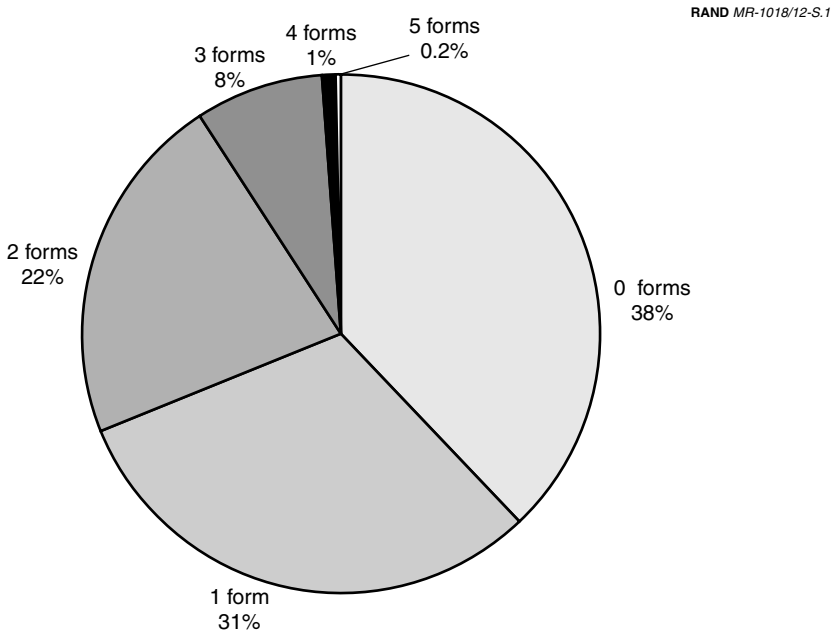

Figure S.1—Number of Personal Pesticide Forms Used

Variations in Use

We also evaluated differences across various subpopulations and found significant differences in living conditions and pesticide use. The most general differ-

ences were by service, where Army personnel used personal pesticides more generally and more frequently, followed by the Marine Corps/Navy. The Air Force used pesticides the least of all the services. This trend holds roughly for field-use pesticides as well, although the Air Force and Marine Corps/Navy reported higher use or observance of "other" sprays.

We found few differences by season when we compared responses for summer (April–October) and winter (November–March). In particular, we found that personal sprays and liquids were more likely to be used by more personnel in the summer, although there was no difference in the frequency of use. Those who wore flea collars, however, wore them less frequently in the summer. We found no other statistically different seasonal differences.

We found some differences in use of personal pesticides by rank. In particular, officers were less likely to use lotions and flea or tick collars, and they used powders less frequently. Senior enlisted personnel used both sprays and powders more frequently. And, although we found some differences in use of field pesticides by rank, we concluded that the differences probably came about because senior personnel were in a position to be more aware of the use of field pesticides, although some of the difference may also be due to differences in living conditions.

Finally, we also found some differences in pesticide use by living arrangements that are consistent with our expectations of how pesticides would be employed. For example, personnel who lived in buildings were less likely to use sprays and liquids, whereas those living in the desert and "other" places were more likely to use these pesticide forms.

Misuse of Pesticides

Given the nature of the survey data, it was difficult to evaluate whether pesticides were used properly because the data were primarily frequency of use by form. Without data on color and smell, it was often not possible to link any given form specifically to an active ingredient. Without the active ingredient, it was not possible to classify misuse in terms of frequency of use. Furthermore, even when the respondent did name a pesticide, our conclusions were still inextricably confounded with recall bias and accuracy issues.

Cases of clear misuse of specific, identifiable pesticides (assuming that the respondents' answers were correct and accurate) included permethrin, d-phenothrin, lindane, and flea or tick collars. However, the number of individuals reporting use of the first three pesticides were very few. The one clear exception, both in terms of identifiability and prevalence of use, is flea or tick collars. We estimate that over 13,000 service members used flea or tick collars

during their tours of duty, and there is little question that the respondents correctly identified and reported the pesticide product.[5] Also, we found evidence that No-Pest strips were sometimes hung in densities greater than recommended by the manufacturers, particularly in some eating areas and latrines.

Field-use pesticides were even more difficult for respondents to identify. We did not find any indications of widespread misuse of field pesticides by the general (untrained) population, and we interpret this lack of information to mean that these pesticides were not available to the general population.

It was similarly difficult to find conclusive evidence of overuse of multiple pesticides because calculating frequency of use by form unavoidably combines various active ingredients in unknown ways. Thus, we could not define an objective measure of "overuse" linked to a specific active ingredient.

The data do show a correlation between high use of personal and field pesticides. This correlation may be the result of seasonal use, so that an increase in pests during one part of the year caused an increase in the use of all pesticides; or the correlation may be the result of location, where those living in the desert and other field environs would be more likely to have used pesticides. It also may be indicative of a reporting bias: People who report high use of one pesticide form are more likely to report high use of another form.

Pesticides and PB Pills

We estimate that approximately 50 percent of the in-theater population, or about 223,500 people, took PB pills at some time during their deployment. Table S.4 shows the usage. Ninety-five percent of the personnel who took PB pills took fewer than three PB pills per day. However, if the respondents' responses are accurate, then 1 percent of the personnel averaged more than three pills per day; in the most extreme cases, seven respondents representing 1,547 personnel reported taking six or more pills per day.

In these data, we find a statistically significant positive association between the number of PB pills taken in a month and the total number of applications of personal-use pesticides. In particular, frequency of use of personal-use sprays and lotions was found to be positively associated with of the number of PB pills taken, even after controlling for other important demographic effects.

---

[5]Of those who used flea collars, more than one-half wore them over their clothes or shoes, which would have helped minimize exposure to the active ingredient. Thus, the evident misuse may or may not have resulted in overexposure.

Table S.4

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	26	1.7	26	1.7	27	1.7	28	1.9
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*.

Figure S.2 demonstrates the association between self-reported 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 some combination of personal-use pesticides 120 times or more in a month.[6] The column on the far right shows the average frequency of use of PB pills among those personnel within each group. For example, the 6 percent who applied personal 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.

Multiple Pesticides

We previously mentioned animal flea or tick collars as a clear example of pesticide misuse. Other personal-use pesticides are more difficult to evaluate in these terms because there was little information allowing us to judge whether levels of use were inappropriate. Figure S.3 plots the distribution of the population with a particular frequency of use for each form of pesticide. It shows, for example, that about 3 percent of the population used sprays more than 100 times a month, or an average of more than three times a day. For a given individual, if the spray was permethrin, such a frequency of use is in excess of the recommended amount.[7] Similarly, about 5 percent of the population used liquids or lotions more than 100 times a month.

---

[6]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.

[7]The DoD Repellent System consists of a 31.5 percent DEET lotion (NSN 6840-01-284-3982) and a permethrin spray (NSN 6840-01-278-1336). Instructions on the product state that the DEET lotion "provides 95% or greater protection against mosquitoes for 12 or more hours under normal use

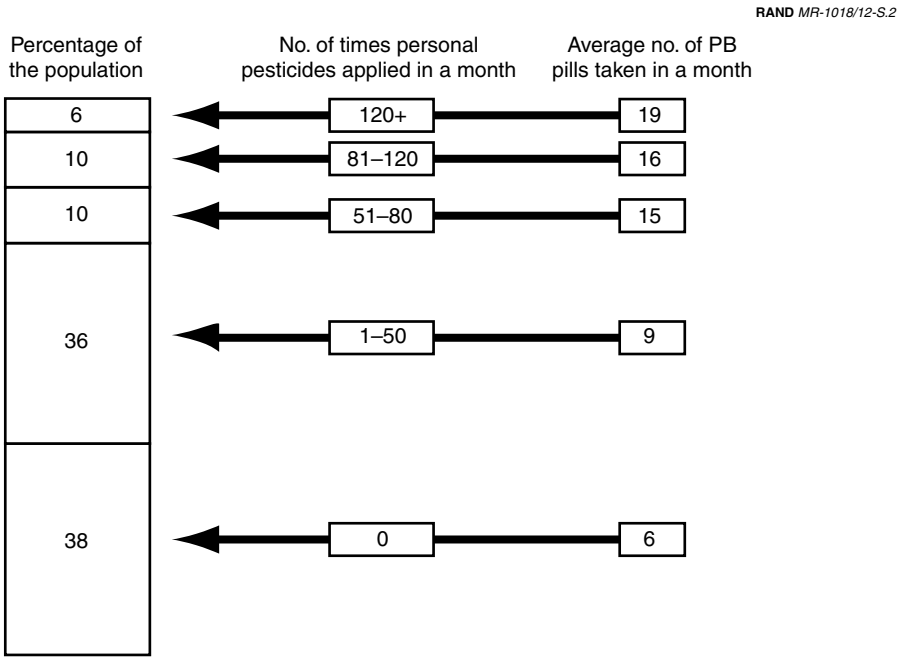

Figure S.2—Frequency of Personal Pesticides Self-Reported Use Compared to Average PB Pill Self-Reported Use

However, Figure S.3 provides information on only one pesticide form at a time. If we consider multiple forms with high use, we estimate that more than 21,000 personnel (4-1/2 percent of the total population) used either sprays more than 120 times a month, liquids more than 100 times a month, or flea collars. Of these, we estimate that slightly more than half (n = 11,064) also took PB pills.

RECOMMENDATIONS

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 they are not routinely trained or tested in their use. They further found that only 40 percent of the personnel surveyed could correctly specify military personal-use pesticide products, more than 90 percent did not treat their uniforms before deployment, and more than 60

conditions. Instructions on the permethrin product state, "reapply after six weeks and sixth laundering."

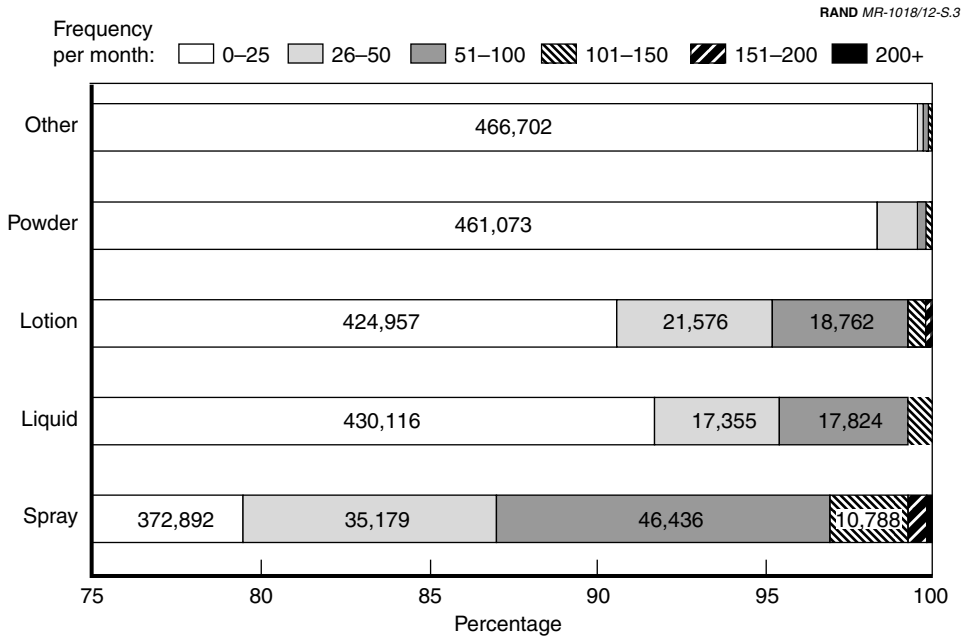

Figure S.3—Frequency of Use of Personal Pesticides by Percentage of the Population

percent of personnel used commercial insect repellents. These results are consistent with our findings that respondents generally could not remember the pesticides they used.

Given that limited formal training is provided to military personnel, it should not be surprising that individuals varied in their application and some tended to overapply in the absence of other guidance. Our data and Gambel et al.'s provide ample evidence for recommending the development and implementation of skill training for military personnel in the proper use of PPMs.

We also find that personnel who reported using more pesticides tended to report taking more PB pills, and a few individuals in our sample reported taking an excessive number of PB pills. Golomb (1999) has suggested that pesticides and PB pills may interact over time. If this is found to be true, then further study of PB pills and pesticides is warranted.

CONCLUSIONS

Evaluating misuse, multiple use, and overuse with these data is difficult at best because, even when the respondent could name a pesticide, our conclusions are still inextricably confounded with recall bias and accuracy issues. For ex-

ample, 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, information on the possible misuse of field pesticides is as likely or more likely to be examples of incorrect identification or reporting than misuse. The one clear example of misuse is use of flea or tick collars, where there is little question that the respondents correctly identified and reported the pesticide product.

However, the difficulty in teasing these effects out of the survey data should not be taken as evidence that they do not exist. 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 using products in ways not recommended. Indeed, as one respondent said, "anything we could get our hands on we would use."

What is clear from this survey is that a large majority of troops were exposed to some of the pesticides present in the Gulf. It is also clear that smaller groups of personnel had unusual pesticide-use patterns, either misusing or applying unusual quantities. Although we do not find clear evidence of widespread misuse of 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.