

ing of the exposure-response association. Model 1 contains the seven primary covariates only. Model 2 contains the 7 primary and 5 secondary covariates. The modeling strategy described here was used with both models.

In evaluating the covariates for effect modification, we first used stepwise multiple logistic regression analysis. All main effects were forced into the model and were not permitted to drop out of the model. Because the covariates are categorical, we used several indicator variables in the model to define each covariate. When potential effect modification was assessed, the several interaction terms pertaining to a single covariate were added (or removed) as a group. This was done by using the BMDP procedure "PLR" (Dixon, 1983). In this procedure, the standard stepwise method was used, with forward selection of variables and then backward elimination. Interaction terms were added to the model in groups if the p-value associated with the F statistic was less than 0.01 for the entire group. Interaction terms already in the model were removed if they did not remain significant at  $p=0.01$ . In this way, we assessed effect modification for all first-order interactions between place of service and the covariates for outcomes with 100 or more total cases for Model 1 and 150 or more total cases for Model 2.

The somewhat stringent significance criterion for detecting effect modification ( $p=0.01$ ) was used to determine whether the OR would be standardized to the distribution of a given covariate in the multivariate analysis. This strategy does not preclude the systematic investigation of risks within subgroups (see Section 2.4.4, Subgroup Analyses). When we found statistically significant effect modification, we standardized the OR using the distribution of the covariates in both cohorts combined (Wilcosky and Chambless, 1985; Flanders and Rhodes, 1987). Stratum-specific odds were estimated from the logistic regression equation and averaged according to the distribution of the covariates.

In the absence of statistically significant effect modification, we calculated all final ORs from the estimated logistic regression coefficients for the independent variable, place of service (Harrell, 1983), and the 95% CI by using the standard errors associated with the maximum likelihood estimates of the regression coefficients and assuming a normal distribution.

Confounding was assessed and controlled through the simultaneous inclusion of all main effects variables in each model. For all outcomes with 25 or more cases, we present ORs adjusted for the seven primary covariates (Model 1). For all outcomes with 50 or more cases, we present ORs adjusted for the primary and secondary covariates (Model 2).

### ***Nonindependence of Child Outcomes***

In the VES interview, veterans could report events for more than one pregnancy or child. Consequently, the events are not independent observations; the events reported for pregnancies or children within a family may be correlated. Because of this lack of independence, the use of standard logistic regression, which assumes independent observations, may not be appropriate. In this situation, the estimates of the regression coefficients from the standard logistic model are still valid, but the standard errors of the estimates may be affected (Liang and Zeger, 1986).

We evaluated the degree of nonindependence among the children by comparing the results of the standard logistic regression method with the results of a modified logistic method that accounts for nonindependence among observations (Appendix C). The modified method yielded standard errors and coefficients similar to those given by the standard logistic model. These comparisons indicate that lack of independence has not

affected the estimates of the betas or their standard errors. Consequently, we have used standard logistic regression techniques, which assume independent observations, in all analyses (Harrell, 1983).

#### 2.4.4 Other Analytic Issues

##### *Treatment of Missing Values*

For virtually every question in the interview, some veterans responded "Don't know" or elected not to give an answer (*i.e.*, "Refused"). For most items, the frequency of such responses was small.

In general, children with an unknown value (*i.e.*, "Don't know" or "Refused") for any particular covariate were excluded from all analyses that included that covariate. For example, crude rates for a particular health outcome are based on counts that include children with missing values of one or more covariates. Children with missing covariate values were, however, excluded from all multivariate analyses involving those covariates. The relative frequencies of missing covariates are shown in Tables 6 and 7.

With respect to health outcomes, the missing data are of two types. The first type concerns a "Don't know" or "Refused" response to an introductory question (*e.g.*, "Were any of your children born with a birth defect?"). For these questions, all such responses are considered a "No" response, and the children of these veterans are retained in the denominator. Table 8 shows that the frequencies of "Refused" responses to these types of questions are small; therefore, for analytic purposes, they are treated the same as the "Don't know" responses.

The second type of missing health outcome data involves the responses to open-ended questions that required names of diseases, conditions, or health problems. Such missing data consist of "Don't know," "Refused," and "Bad data" codes. (A "bad data" code was used when a response was indecipherable and could not be otherwise coded. The relative frequencies of these three types of missing data (combined) for the responses to the open-ended birth-defect, serious-health-problem, childhood-cancer, and cause-of-infant-death questions are 1.1%, 0.4%, 5.3%, and 5.5%, respectively. Children whose fathers gave a "Don't know," "Refused," or uncodable response to an open-ended question following an affirmative response to the introductory question are counted as a case only in analyses of responses to the introductory question.

**Table 8. Percent and Number of Veterans Giving a "Don't Know" or "Refused" Response to Introductory Questions About Their Children's Health**

Question	Vietnam				Non-Vietnam			
	Don't Know		Refused		Don't Know		Refused	
	%	No.	%	No.	%	No.	%	No.
Were any of your children born with a birth defect...?	0.3	19	<0.1	2	0.1	7	<0.1	2
Did any of your children have any serious health problems...?	0.8	48	0.0	0	0.6	36	<0.1	2
Did any of your children ever develop leukemia or cancer?	0.6	37	0.0	0	0.5	31	<0.1	1
Are all of your live-born children still living?	0.2	10	0.0	0	0.1	8	0.0	0
How many pregnancies have you fathered that ended in a miscarriage, induced abortion, or tubal pregnancy?	0.3	27	0.3	25	0.3	24	0.4	28

### ***Subgroup Analyses***

We did two types of subgroup analyses for selected outcomes. In the first, we compared children of Vietnam and non-Vietnam veterans at each level of the following covariates: age, race, GT score, enlistment status, and number of years between entry into the Army and birth (or other event). Potential subgroup differences in the association of Vietnam service with health outcomes were examined for miscarriages, stillbirths, birth defects, serious health problems, and infant mortality. Results for all subgroups have been presented.

In the second type of subgroup analysis, we defined subgroups among men who served in Vietnam only. These subgroups may differ in terms of experiences in Vietnam, perceptions of those experiences, and subsequent reporting of child health outcomes. We examined associations with five components of the Vietnam experience: self-reported combat exposure, self-reported drug use in the Army, perceived herbicide exposure, year of entry into the Army, and primary military occupational specialty. The construction of indices of exposure for self-reported combat and herbicide exposure is described fully in Volume II, Appendix E. These subgroup analyses were done for miscarriages, stillbirths, birth defects, serious health problems, and infant mortality. To calculate an OR for each outcome, we compared children fathered by each exposure subgroup of Vietnam veterans with children fathered by the subgroup of Vietnam veterans reporting the lowest category of exposure. Each multivariate result is adjusted for all other components of the Vietnam experience. Numbers and crude rates for each outcome among children of non-Vietnam veterans are also presented for comparison.

### ***Secondary Comparison Groups***

While the general analysis format uses all non-Vietnam veterans as the comparison group, we have also used subgroups of the non-Vietnam veterans as secondary reference groups. Men who were assigned overseas, but not to Vietnam, may be more comparable to Vietnam veterans than those who remained in the United States for their entire enlistment period. To investigate this possibility, we defined two comparison groups: men who served in Germany or Korea and men who served only in the continental United States. Both groups were used as a comparison for the following outcome categories: miscarriages, stillbirths, birth defects, serious health problems, and infant mortality.

### 3. RESULTS

The rates of reproductive and child health outcomes described in this section are based on several fixed counts of pregnancies and births in each cohort (Table 9). These counts represent conceptions that occurred after the veterans' military experience. The discussion of each outcome and the corresponding tables of results specify the denominator used in each analysis. Table 9 also gives the number of veterans in each cohort and the mean number of pregnancies and births per veteran.

In most instances, odds ratios (ORs) derived from multivariate analyses (*i.e.*, Models 1 and 2) are very similar to the crude ORs. Consequently, to simplify description of the results, we refer to the crude ORs in the text unless adjustment (or standardization) produces a very different point estimate. The latter type of situation has been pointed out where appropriate.

#### 3.1 ADVERSE PREGNANCY OUTCOMES

Vietnam veterans were more likely to report having fathered a pregnancy that ended in a miscarriage than non-Vietnam veterans (crude OR=1.2, 95% CI=1.1-1.3) (Table 10). This relative excess remained after the results were adjusted for the primary and secondary covariates. In general, the odds of miscarriage associated with Vietnam service were elevated, regardless of the trimester in which the miscarriage was reported to have occurred, and the ORs varied little across trimesters.

Vietnam veterans were not more likely than non-Vietnam veterans to report the other reproductive outcomes examined—pregnancies ending in an induced abortion, tubal pregnancies, and stillbirths (Tables 10 and 11); adjustment for the effects of potential confounders did not change these results.

The percent of male live births is close to 51% for both Vietnam and non-Vietnam veterans; the corresponding crude OR is 1.0 (Table 12). For stillbirths, the percent of male births is elevated among children of Vietnam veterans (57.9%), yielding a crude OR of 1.4. This OR is not, however, significantly different from 1.0 at the 0.05 level.

**Table 9. Number of Veterans, Numbers of Births and Pregnancies Conceived After Assignment to Primary Tour of Duty Among Vietnam and Non-Vietnam Veterans, and Mean Number of Pregnancies and Births Per Veteran**

	Vietnam		Non-Vietnam	
	No.	No. per Veteran	No.	No. per Veteran
Total Veterans	7924	—	7364	—
Total Pregnancies	15009 <sup>a</sup>	1.9	13715 <sup>a</sup>	1.9
Abortive Pregnancies	2221 <sup>a</sup>		1805 <sup>a</sup>	
Miscarriage	1566		1190	
Induced abortion	527		487	
Tubal pregnancy	122		122	
Other	6		6	
Total Births	12788	1.6	11910	1.6
Live birth	12659	1.6	11777	1.6
Stillbirth	126		131	
Unknown	3		2	

<sup>a</sup> Excluded are 19 abortive pregnancies among Vietnam veterans and 7 among non-Vietnam veterans for which type of abortive pregnancy and date of event are missing.

**Table 10. Number of Selected Adverse Pregnancy Outcomes, Crude Rates Per 100 Total Pregnancies Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=15009)		Non-Vietnam (N=13715)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
Miscarriage	10.4	1566	8.7	1190	1.2	1.1-1.3	1.3	1.2-1.4	1.2	1.1-1.3
First trimester	7.6	1145	6.2	846	1.3	1.1-1.4	1.3	1.2-1.4	1.3	1.2-1.4
Second trimester	2.1	321	1.9	265	1.1	0.9-1.3	1.1	0.9-1.3	1.0	0.9-1.2
Third trimester	0.1	21	0.1	18	1.1	0.6-2.0	1.3	0.7-2.5	—	—
Unknown trimester	0.5	79	0.4	61	1.2	0.8-1.7	1.3	0.9-1.9	1.2	0.8-1.7
Induced Abortion	3.5	527	3.6	487	1.0	0.9-1.1	1.0 <sup>c</sup>	0.9-1.2	0.9 <sup>d</sup>	0.8-1.0
Tubal Pregnancy	0.8	122	0.9	122	0.9	0.7-1.2	1.0 <sup>c</sup>	0.7-1.2	0.9 <sup>c</sup>	0.7-1.1

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Standardized for General Technical test score.

<sup>d</sup> Standardized for current marital status and alcohol consumption.

**Table 11. Number of Reported Stillbirths, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=12788)		Non-Vietnam (N=11910)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
Stillbirth	9.9	126	11.0	131	0.9	0.7-1.1	0.9	0.7-1.1	0.9	0.7-1.1

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

**Table 12. Number and Percent of Male Children Fathered by Vietnam and Non-Vietnam Veterans and Odds Ratios for Fathering a Male Child, by Vital Status at Birth**

Vital Status	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	%	No.	%	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
Live birth	51.4	6511	51.1	6019	1.0	1.0-1.1	1.0	1.0-1.1	1.0	1.0-1.1
Stillbirth	57.9	73	50.4	66	1.4	0.8-2.2	1.3	0.7-2.2	1.2	0.7-2.2

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

About 12% of all pregnancies reported in the VES interview were conceived before the veteran's military experience and, consequently, could not have been influenced by any exposures associated with the experience. To define a baseline, or preexposure, risk, we compared the rates of miscarriage among pregnancies fathered by Vietnam and non-Vietnam veterans that were conceived before the veteran's primary tour of duty (and pregnancies with unknown dates of conception) (Table 13). There is no difference in the risk of miscarriage among pregnancies conceived during the preexposure period (crude OR=0.9).

### 3.2 BIRTH DEFECTS

Vietnam veterans reported more birth defects in their children than did non-Vietnam veterans, with the rates for each cohort being 64.6 per 1,000 total births and 49.5 per 1,000 total births, respectively (Table 14). These results produce a crude OR of 1.3 for total birth

**Table 13. Number of Reported Miscarriages Among Pregnancies Conceived Prior to the Veteran's Primary Tour of Duty, Crude Rates Per 100 Total Pregnancies Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=2000)		Non-Vietnam (N=1851)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Miscarriages	17.1	342	17.9	331	0.9	0.8-1.1	1.0	0.7-1.3	1.0	0.7-1.4

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

**Table 14. Number of Children With Reported Birth Defects, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Defect Category <sup>c</sup>	Vietnam (N=12788)		Non-Vietnam (N=11910)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Total anomalies	64.6	826	49.5	590	1.3	1.2-1.5	1.3	1.2-1.4	1.3	1.1-1.4
Nervous system	2.6	33	1.1	13	2.4	1.2-4.5	2.3	1.2-4.5	-	-
Eye	1.6	20	1.1	13	1.4	0.7-2.9	1.3	0.7-2.8	-	-
Ear, face, neck	2.9	37	1.8	22	1.6	0.9-2.7	1.6	0.9-2.8	1.4	0.8-2.5
Circulatory	6.7	86	6.1	73	1.1	0.8-1.5	1.1	0.8-1.6	1.2	0.8-1.6
Respiratory	1.2	15	0.8	10	1.4	0.6-3.1	1.5	0.6-3.5	-	-
Digestive system	8.4	108	6.8	81	1.2	0.9-1.7	1.2	0.9-1.6	1.2	0.9-1.6
Genital	2.7	35	2.3	27	1.2	0.7-2.0	1.3	0.8-2.2	1.2	0.7-2.0
Urinary system	3.6	46	2.4	28	1.5	1.0-2.5	1.4	0.9-2.3	1.3	0.8-2.1
Musculoskeletal	33.3	426	25.9	309	1.3	1.1-1.5	1.2	1.1-1.5	1.2	1.0-1.4
Integument	3.2	41	1.4	17	2.3	1.3-4.0	2.2	1.2-4.0	2.4	1.3-4.3
Chromosomal	0.8	10	1.0	12	0.8	0.3-1.8	-	-	-	-
Other unspecified	1.6	20	0.8	10	1.9	0.9-4.0	1.7	0.8-3.9	-	-

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> See Table 2 for complete title and ICD-9 codes for each category.

defects among children of Vietnam veterans (95% CI = 1.2-1.5). This excess is not caused by any single organ system or defect category; the uniform elevation in each defect category explains the elevation in the rate of total reported birth defects among children of Vietnam veterans. The ORs for nervous system anomalies and anomalies of the integument are both over 2.0 and are both significant. The excess risk for reported musculoskeletal deformities (crude OR = 1.3) is also statistically significant.

The largest single category of birth defects reported in both cohorts is musculoskeletal deformities. These account for over half of all reported defects. On closer examination, we found that 47% of the musculoskeletal deformities reported in each cohort consisted of varus and valgus deformities of the feet and other and unspecified limb anomalies. These are, for the most part, positional deformities or minor anomalies.

Results for selected birth defects that are thought to be relatively common, easily diagnosed, and observable at birth are shown in Table 15. Most defects listed have ORs greater than 1.0, but the numbers of cases are small, and the excess is significant only for hydrocephalus (crude OR = 5.1, 95% CI = 1.1-23.1).

**Table 15. Number of Children With Reported Selected Defects, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Birth Defect <sup>b</sup>	Vietnam (N=12788)		Non-Vietnam (N=11910)		Crude Results		Multivariate Results Model 1 <sup>a</sup>	
	Rate	No.	Rate	No.	OR	95% CI	OR	95% CI
Anencephaly	0.2	3	0.0	0	—	—	—	—
Spina bifida	0.7	9	0.4	5	1.7	0.6-5.0	—	—
Hydrocephalus	0.9	11	0.2	2	5.1	1.1-23.1	—	—
Cleft palate	0.9	11	0.9	11	0.9	0.4-2.1	—	—
Total cleft lip	1.2	15	0.9	11	1.3	0.6-2.8	1.3	0.6-2.8
Cleft lip and palate	2.0	26	1.8	22	1.1	0.6-1.9	1.0	0.5-1.8
Esophageal atresia	0.3	4	0.3	3	1.2	0.3-5.5	—	—
Anorectal atresia	0.4	5	0.4	5	0.9	0.3-3.2	—	—
Hypospadias	0.8	10	0.3	3	3.1	0.9-11.3	—	—
Dislocated hip	1.9	24	1.6	19	1.2	0.6-2.1	1.2	0.6-2.2
Polydactyly	1.3	16	1.1	13	1.1	0.6-2.4	1.3	0.6-2.8
Reduction deformities	0.9	12	1.1	13	0.9	0.4-1.9	1.0	0.4-2.2
Down's syndrome	0.8	10	0.9	11	0.8	0.4-2.0	—	—

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> See Table 3 for complete name and ICD-9 code for each defect.

Vietnam veterans report more multiple defects in their children than do non-Vietnam veterans (Table 16). The crude OR for reporting a child with more than one birth defect is 1.6 compared with an OR of 1.3 for reporting a child with only one defect. Further, Vietnam veterans are at excess risk (crude OR=1.5) of reporting two or more children with birth defects (Table 17). Their excess risk of reporting only one child with a birth defect is not as great (crude OR=1.3).

To determine if the specificity of veterans' responses to the birth defect questions differed by cohort, we excluded from the analysis of total birth defects any ICD-9 code falling within the range 740.0-759.9 but ending in a fourth digit of 8 or 9. (Codes ending in 8 and 9 are generally used to code "other" and "unspecified" conditions.) This excluded 19.1% of the children with birth defects in the Vietnam cohort and 17.8% in the non-Vietnam cohort. The resulting crude OR is 1.3 (95% CI=1.2-1.5).

**Table 16. Number of Children With Only One Reported Birth Defect and With More Than One Reported Birth Defect, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Numerator	Vietnam (N=12788)		Non-Vietnam (N=11910)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
Children with only one defect	59.0	755	46.0	548	1.3	1.2-1.5	1.3	1.1-1.4	1.2	1.1-1.4
Children with more than one defect	5.6	71	3.5	42	1.6	1.1-2.3	1.6	1.1-2.5	1.6	1.1-2.4

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

**Table 17. Number of Veterans Reporting One Child With Birth Defects and Number Reporting Two or More Children With Birth Defects, Crude Rates Per 100 Veterans With Children, and Crude and Adjusted Odds Ratios**

Numerator	Vietnam (N=6113)		Non-Vietnam (N=5665)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Veterans reporting one child with a birth defect	10.5	644	8.4	473	1.3	1.1-1.5	1.2	1.1-1.4	1.2	1.1-1.4
Veterans reporting more than one child with a birth defect	1.4	86	0.9	52	1.5	1.1-2.2	1.5	1.0-2.1	1.4	1.0-2.0

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

About 11% of all children reported in the VES interview were conceived before the veterans' military experience. To define a baseline association, we compared the rates of total birth defects among children of Vietnam and non-Vietnam veterans who were conceived before the veteran's primary tour of duty and children with unknown dates of birth (Table 18). There is a significant excess risk among children of Vietnam veterans who were conceived during this preexposure period (crude OR = 1.6, 95% CI = 1.1-2.5).

### 3.3 CANCER

There are 25 and 17 reported childhood cancers among children of Vietnam and non-Vietnam veterans, respectively (crude OR = 1.4, 95% CI = 0.7-2.5) (Table 19). When childhood cancers were examined by specific type (Table 20), the largest group of reported cancers among both veteran groups was leukemia. The excess of reported childhood leukemia among children of Vietnam veterans (crude OR = 1.6) is not statistically significant (95% CI = 0.6-4.0). Very few cases of other types of cancer were reported in either group, and no meaningful statistical analysis could be done.

### 3.4 OTHER SERIOUS HEALTH PROBLEMS

Over half of the reported serious health problems that occurred among veterans' children during the first 5 years of life are attributed to respiratory disease (mostly asthma and pneumonia) and nervous system disease (primarily otitis media) (Table 21). For the great majority of disease categories shown, Vietnam veterans report more health problems in their children than do non-Vietnam veterans; the crude OR for all reported conditions is 1.3 (95% CI = 1.2-1.4).

**Table 18. Number of Children With Reported Birth Defects Among Those Children Conceived Prior to the Veteran's Primary Tour of Duty, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=1473)		Non-Vietnam (N=1330)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Total anomalies	40.7	60	25.6	34	1.6	1.1-2.5	1.7	1.1-2.7	1.7	1.1-2.7

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.



**Table 19. Number of Children With Reported Cancer, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=12659)		Non-Vietnam (N=11777)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Childhood cancer	2.0	25	1.4	17	1.4	0.7-2.5	1.5	0.7-2.8	—	—

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

**Table 20. Distribution of Reported Childhood Cancers Among Offspring of Veterans, by Place of Service**

Cancer Type	ICD-9 Codes	Vietnam No.	Non-Vietnam No.
Leukemia*	204,205	12 208	7
Other lymphoid	201,202	2	2
Gastrointestinal	151,159	1	1
Wilms' tumor	189	2	0
Eye	190	1	0
Brain	191	1	1
Neuroblastoma, adrenal cortex, unspecified	194	1	4
Other, ill-defined	195,199	4	2
Unknown		1	0
Total		25	17

\* Odds ratio (VN/non-VN) for reported leukemia is 1.6 (95% CI=0.6-4.0).

The ORs for several of the disease categories are significantly different from 1.0. Among these categories are anemias (crude OR=2.0, 95% CI=1.2-3.3), diseases of the skin (crude OR=1.5, 95% CI=1.1-1.9), symptoms and signs (crude OR=1.4, 95% CI=1.2-1.7), rash (crude OR=2.3, 95% CI=1.1-4.9), and allergies (crude OR=1.6, 95% CI=1.2-2.1).

Because birth defects and cancer were asked about specifically and found to be elevated among children of Vietnam veterans, and because these conditions can lead to other serious health problems, we analyzed the data for total serious health problems excluding those children who were reported to have a birth defect or cancer. After excluding 251 children of Vietnam veterans and 169 children of non-Vietnam veterans with a reported serious health problem and a birth defect or cancer, we found the crude OR to be 1.2 (95% CI=1.1-1.3).

To define a baseline association, we compared the rates of total serious health problems among children of Vietnam and non-Vietnam veterans who were conceived before the veteran's primary tour of duty (and children with unknown dates of birth) (Table 22). There is no difference in the risk of serious health problems among children who were conceived during this preexposure period (crude OR=1.0, 95% CI=0.8-1.4).

### 3.5 MORTALITY

Results of an analysis of child mortality patterns (Table 23) showed no excess of reported child deaths among Vietnam veterans compared with non-Vietnam veterans (crude OR=1.1,

95% CI=0.7-1.8). Overall, infants of Vietnam veterans were not reported to die more frequently than infants of non-Vietnam veterans (crude OR = 1.0) (Table 23). There is a small, but not statistically significant, excess of infant deaths due to congenital malformations among children of Vietnam veterans compared with children of non-Vietnam veterans (crude OR = 1.3; 95% CI = 0.7-2.3) (Table 24).

### 3.6 SPECIAL ANALYSES FOR SELECTED HEALTH OUTCOMES

#### 3.6.1 Subgroups of All Veterans

For the five health outcomes examined (miscarriages, stillbirths, birth defects, serious health problems, and infant mortality), the association of Vietnam service with the outcomes

**Table 21. Number of Children With Reported *Serious Health Problems*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Problem Category <sup>c</sup>	Vietnam (N = 12659)		Non-Vietnam (N = 11777)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>	95% CI	OR	95% CI
All Reported Conditions	158.9	2011	130.1	1532	1.3	1.2-1.4	1.3	1.2-1.4	1.3	1.2-1.4
Infectious and Parasitic Diseases	5.7	72	4.2	50	1.3	0.9-1.9	1.3	0.9-1.9	1.3	0.9-1.9
Bacterial disease	2.4	30	2.0	24	1.2	0.7-2.0	1.2	0.7-2.0	1.2	0.7-2.1
Viral disease	1.9	24	1.6	19	1.2	0.6-2.1	1.1	0.6-2.0	—	—
Benign and Unspecified Neoplasms	2.1	26	1.5	18	1.3	0.7-2.5	1.3	0.7-2.5	—	—
Endocrine Diseases	3.1	39	3.0	35	1.0	0.7-1.6	1.0	0.7-1.7	1.0	0.6-1.7
Diabetes	0.5	6	0.8	9	0.6	0.2-1.7	—	—	—	—
Dehydration	0.8	10	0.7	8	1.2	0.5-2.9	—	—	—	—
Diseases of the Blood	4.5	57	2.6	31	1.7	1.1-2.7	1.7	1.1-2.7	1.7	1.0-2.6
Anemias	3.5	44	1.8	21	2.0	1.2-3.3	1.9	1.1-3.2	1.9	1.1-3.4
Mental Disorders	6.2	78	4.7	55	1.3	0.9-1.9	1.3	0.9-1.9	1.3	0.9-1.9
Hyperkinetic activity	2.7	34	2.4	28	1.1	0.7-1.9	1.1	0.7-1.9	1.1	0.7-1.9
Developmental disorders	2.0	25	1.1	13	1.8	0.9-3.5	1.9	1.0-3.9	—	—
Nervous System Diseases	34.8	441	29.1	343	1.2	1.0-1.4	1.2	1.0-1.4	1.2	1.0-1.4
Meningitis	3.2	41	2.3	27	1.4	0.9-2.3	1.3	0.8-2.2	1.4	0.8-2.3
Epilepsy	1.7	22	1.2	14	1.5	0.7-2.9	1.6	0.8-3.1	—	—
Strabismus	3.3	42	4.8	57	0.7	0.5-1.0	0.7	0.4-1.0	0.6	0.4-1.0
Other eye disorders	2.6	33	3.0	35	0.9	0.5-1.4	0.9	0.5-1.5	0.9	0.5-1.4
Diseases of ear	21.8	276	16.9	199	1.3	1.1-1.6	1.3	1.1-1.6	1.3	1.1-1.6
Circulatory System Dis.	1.5	19	1.5	18	1.0	0.5-1.9	0.9	0.5-1.8	—	—
Respiratory System Dis.	47.6	602	41.5	489	1.2	1.0-1.3	1.1	1.0-1.3	1.1	1.0-1.3
Tonsillitis	3.2	40	2.9	34	1.1	0.7-1.7	1.1	0.7-1.7	1.1	0.7-1.8
Allergic rhinitis	4.3	55	3.4	40	1.3	0.9-1.9	1.3	0.8-2.0	1.3	0.9-2.0
Pneumonia	9.2	116	8.7	102	1.1	0.8-1.4	1.0	0.8-1.3	1.0	0.7-1.3
Bronchitis	5.3	67	3.7	43	1.5	1.0-2.1	1.4	1.0-2.1	1.4	0.9-2.1
Asthma	22.7	287	19.8	233	1.1	1.0-1.4	1.2	1.0-1.4	1.2	1.0-1.4
Digestive System Dis.	11.1	141	10.4	122	1.1	0.8-1.4	1.1 <sup>d</sup>	0.8-1.4	1.1 <sup>d</sup>	0.8-1.4
Hernia	5.8	74	6.5	77	0.9	0.6-1.2	0.9	0.6-1.3	0.9	0.6-1.2
Genitourinary System Diseases	5.2	66	3.8	45	1.4	0.9-2.0	1.3	0.9-1.9	1.3	0.9-1.9
Urinary tract infection	2.4	31	1.7	20	1.4	0.8-2.5	1.3	0.7-2.3	1.3	0.7-2.4

**Table 21. Number of Children With Reported *Serious Health Problems*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios – Continued**

Problem Category <sup>c</sup>	Vietnam (N = 12659)		Non-Vietnam (N = 11777)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Diseases of the Skin	10.0	126	6.8	80	1.5	1.1-1.9	1.5	1.1-2.0	1.5	1.1-2.0
Dermatitis	5.8	74	4.8	57	1.2	0.9-1.7	1.2	0.9-1.8	1.3	0.9-1.8
Musculoskeletal Disease	2.8	35	1.4	17	1.9	1.1-3.4	1.8	1.0-3.3	1.9	1.0-3.4
Perinatal Conditions	6.1	77	5.0	59	1.2	0.9-1.7	1.3	0.9-1.8	1.3	0.9-1.8
Jaundice	2.8	36	3.0	35	1.0	0.6-1.5	1.0	0.6-1.7	1.0	0.6-1.7
Symptoms and Signs	20.1	255	14.2	167	1.4	1.2-1.7	1.5	1.2-1.8	1.4	1.2-1.8
Convulsions	4.6	58	2.9	34	1.6	1.0-2.4	1.6	1.0-2.5	1.6	1.0-2.5
Fever unknown origin	1.6	20	1.0	12	1.6	0.8-3.2	1.4	0.7-3.0	—	—
Rash	2.0	25	0.8	10	2.3	1.1-4.9	2.3	1.1-4.9	—	—
Speech disturbance	2.7	34	2.2	26	1.2	0.7-2.0	1.3	0.8-2.3	1.3	0.7-2.2
Cardiac murmur	3.2	40	3.3	39	1.0	0.6-1.5	1.1	0.7-1.7	1.1	0.7-1.7
Injuries and Poisoning	12.7	161	8.1	95	1.6	1.2-2.0	1.6 <sup>e</sup>	1.2-2.1	1.6 <sup>e</sup>	1.2-2.0
Allergies unspecified	10.3	131	6.6	78	1.6	1.2-2.1	1.6 <sup>e</sup>	1.2-2.1	1.6 <sup>e</sup>	1.2-2.1
Supplementary Classification	3.2	40	2.4	28	1.3	0.8-2.2	1.3	0.8-2.1	1.2	0.7-2.0
Problems internal	2.1	27	1.3	15	1.7	0.9-3.2	1.6	0.9-3.1	—	—

- <sup>a</sup> Model 1 contains the primary covariates.  
<sup>b</sup> Model 2 contains the primary and secondary covariates.  
<sup>c</sup> See Table 4 for complete title and ICD-9 codes for each category.  
<sup>d</sup> Standardized for primary military occupational specialty.  
<sup>e</sup> Standardized for veteran's race.

**Table 22. Number of Children With Reported *Serious Health Problems* Among Those Children Conceived Prior to the Veteran's Primary Tour of Duty, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N = 1404)		Non-Vietnam (N = 1260)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Total serious health problems	80.5	113	78.6	99	1.0	0.8-1.4	1.1	0.8-1.5	1.2	0.9-1.6

- <sup>a</sup> Model 1 contains the primary covariates.  
<sup>b</sup> Model 2 contains the primary and secondary covariates.

**Table 23. Number of Reported *Infant and Child Deaths*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N = 12659)		Non-Vietnam (N = 11777)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Infant mortality	12.0	152	11.8	139	1.0	0.8-1.3	1.0 <sup>c</sup>	0.8-1.3	1.0 <sup>c</sup>	0.8-1.3
Child mortality <sup>d</sup>	3.3	41	2.9	34	1.1	0.7-1.8	1.1	0.7-1.8	1.1	0.7-1.8

- <sup>a</sup> Model 1 contains the primary covariates.  
<sup>b</sup> Model 2 contains the primary and secondary covariates.  
<sup>c</sup> Standardized for type of enlistment. Stratum-specific ORs are presented in Table 29.  
<sup>d</sup> The denominator for child mortality rates is live births minus infant deaths.

**Table 24. Number of Reported *Infant Deaths*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios**

Condition	Vietnam (N=12659)		Non-Vietnam (N=11777)		Crude Results		Multivariate Results			
	Rate	No.	Rate	No.	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Prematurity and low birth weight	2.8	36	2.5	30	1.1	0.7-1.8	1.2	0.7-2.0	1.3	0.8-2.2
Respiratory distress	1.4	18	2.0	24	0.7	0.4-1.3	0.7	0.4-1.4	-	-
Other perinatal conditions	0.9	11	0.9	11	0.9	0.4-2.1	-	-	-	-
Congenital malformations	2.3	29	1.8	21	1.3	0.7-2.3	1.2	0.6-2.1	2	0.6-2.1
Sudden infant death syndrome	1.6	20	1.6	19	1.0	0.5-1.8	0.9	0.4-1.7	-	-
Infectious disease	0.5	6	0.2	2	-	-	-	-	-	-
Injury and poisoning	0.2	2	0.1	1	-	-	-	-	-	-
Other	2.4	30	2.6	31	0.9	0.5-1.5	0.9	0.5-1.4	0.8	0.5-1.4

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

is generally similar within subgroups of selected covariates (Tables 25 to 29). Some patterns of subgroup differences, however, can be observed for miscarriages, total birth defects, and infant death.

For miscarriages (Table 25), and birth defects (Table 27), the OR for Vietnam service is highest among children born to veterans 25 years of age or less, and lowest among those born to fathers 31 years of age or older. For both of these outcomes, there is also an inverse relationship between the magnitude of the OR and the number of years between the veteran's entry into the Army and the birth of the child (or the time of the miscarriage).

For birth defects, ORs among children of white and black veterans are greater than 1.0, but the OR for children of Hispanic and other race fathers is less than 1.0 (Table 27). The OR for children of white veterans is greater than 1.0 for infant mortality, while the ORs for children of nonwhite veterans are less than 1.0 (Table 29).

Finally, the OR for Vietnam service and infant death is greater among children of enlisted veterans (crude OR=1.6) than among children of draftees (crude OR=0.8) (Table 29).

### 3.6.2 Subgroups of Vietnam Veterans

With the exception of miscarriages, none of the outcomes examined vary significantly by the veteran's reported combat exposure (Table 30-34). Miscarriages show a modest trend of increasing ORs with increasing reported combat exposure; there is a significant excess of reported miscarriage among children of veterans reporting "high" combat (crude OR=1.3) and "very high" combat (crude OR=1.3) when compared with children of veterans reporting "low" combat. The ORs for the other outcomes examined (Tables 25-29) are not significantly different from 1.0.

A much stronger and more consistent trend is seen when children are categorized according to veterans' reported herbicide exposure. There is a clear pattern of increasing ORs with increasing reported herbicide exposure for miscarriages, birth defects, serious health problems, and infant mortality (Tables 30, 32-34). This trend persists for all outcomes after adjustment for the primary and secondary covariates. The strongest association with

**Table 25. Number of Reported Miscarriages, Crude Rates Per 100 Total Pregnancies Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios, by Selected Covariates**

Characteristic (of Veteran)	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	Rate	No. <sup>c</sup>	Rate	No. <sup>c</sup>	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Age at Birth of Child										
≤25	11.3	561	8.7	384	1.3	1.2-1.5	1.4	1.2-1.6	1.4	1.2-1.6
26-30	9.5	554	7.9	420	1.2	1.1-1.4	1.3	1.1-1.4	1.2	1.1-1.4
31+	10.6	451	9.6	386	1.1	1.0-1.3	1.2	1.0-1.3	1.1	1.0-1.3
Race										
White	10.5	1274	8.7	951	1.2	1.1-1.3	1.3	1.2-1.4	1.2	1.1-1.4
Black	10.3	186	8.0	133	1.3	1.0-1.7	1.3	1.1-1.7	1.3	1.0-1.6
Hispanic and other	10.1	106	9.4	106	1.1	0.8-1.4	1.1	0.8-1.5	1.1	0.8-1.5
General Technical (GT) Test Score										
40-89	10.8	426	8.8	278	1.3	1.1-1.5	1.3	1.1-1.5	1.2	1.1-1.5
90-109	10.1	509	7.4	328	1.4	1.2-1.6	1.4	1.2-1.7	1.4	1.2-1.6
110-129	10.6	491	9.1	406	1.2	1.0-1.4	1.2	1.1-1.4	1.2	1.0-1.3
130-160	9.8	119	10.4	167	0.9	0.7-1.2	1.0	0.8-1.2	1.0	0.7-1.2
Enlistment Status										
Drafted	10.2	986	8.5	784	1.2	1.1-1.3	1.3	1.1-1.4	1.2	1.1-1.4
Enlisted	10.9	580	9.0	406	1.2	1.1-1.4	1.3	1.1-1.5	1.3	1.1-1.4
Years Between Entry and Birth <sup>d</sup>										
1	30.0	15	15.9	34	2.3	1.1-4.6	2.3	1.1-4.6	2.1	1.0-4.3
2	13.8	65	8.7	61	1.7	1.2-2.4	1.8	1.2-2.6	1.8	1.2-2.6
3-5	10.8	437	8.2	287	1.4	1.2-1.6	1.4	1.2-1.6	1.4	1.2-1.6
6-10	9.7	584	7.9	420	1.3	1.1-1.4	1.3	1.1-1.5	1.3	1.1-1.4
11+	10.5	465	9.8	388	1.1	0.9-1.2	1.1	1.0-1.3	1.1	0.9-1.3

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> This covariate has been divided into more categories for the purpose of subgroup analyses.

reported herbicide exposure is seen for infant mortality (Table 34). The crude OR for the "high herbicide exposure" group is 2.2 (Model 2 OR=2.8, 95% CI=1.4-5.5). The ORs for miscarriages, birth defects, and serious health problems in the "high herbicide exposure" group are less than 2.00. There is no trend of increasing ORs with increasing reported herbicide exposure for stillbirths (Table 31).

The three other components of the Vietnam experience (reported drug use in the Army, year of entry into the Army, and primary military occupational specialty) do not appear to contribute to variation in the outcomes examined. There is a suggestion of higher ORs with hard drug use in the Army for both stillbirths and birth defects, but in neither case are these ORs significantly different from 1.0.

### 3.6.3 Secondary Comparison Groups

The risk associated with service in Vietnam is not appreciably altered by the comparison group used (Tables 35-39). This finding is consistent across all outcomes examined.

## 4. DISCUSSION

For most reproductive and child health outcomes studied, Vietnam veterans were more likely to report an adverse event than were non-Vietnam veterans. This applies specifically to miscarriages, total and individual birth defects, multiple defects, cancer, and total and individual serious health problems. The exceptions to this pattern were induced abortions, tubal pregnancies, stillbirths, and mortality. This tendency to report more adverse events for their children is consistent with the Vietnam veterans' reporting more adverse events with regard to their own health status (see Volume II). The observed excess in reported events could be due to true differences in risk between children in the two cohorts (existing before military service or related to military service), to differences in health care-seeking behavior or access to medical services, or to differential reporting (*i.e.*, the manner, extent, and accuracy of reporting) between Vietnam and non-Vietnam veterans.

We begin our discussion of these results by reviewing the strengths and limitations of our study design, data quality, and analytic methods.

### 4.1 STUDY GROUP

A major strength of the VES is the set of stringent criteria defining the study group (see Volume II). These criteria delineated the largest subgroup of military personnel stationed in

**Table 26. Number of Reported *Stillbirths*, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios, by Selected Covariates**

Characteristic (of Veteran)	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	Rate	No. <sup>c</sup>	Rate	No. <sup>c</sup>	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Age at Birth of Child										
≤25	12.1	51	14.3	55	0.8	0.6-1.2	0.8	0.6-1.2	0.8	0.6-1.2
26-30	9.8	49	9.4	44	1.1	0.7-1.6	1.0	0.7-1.5	1.0	0.7-1.5
31+	7.3	26	9.4	32	0.8	0.5-1.3	0.8	0.5-1.3	0.8	0.5-1.3
Race										
White	9.2	95	10.1	96	0.9	0.7-1.2	0.9	0.7-1.2	0.9	0.7-1.2
Black	15.0	23	18.3	26	0.8	0.5-1.4	0.8	0.5-1.4	0.8	0.5-1.4
Hispanic and other	8.9	8	9.3	9	1.0	0.4-2.5	1.0	0.4-2.6	1.0	0.4-2.5
General Technical (GT) Test Score										
40-89	13.8	47	16.0	44	0.9	0.6-1.3	0.9	0.6-1.3	0.9	0.6-1.3
90-109	9.7	42	8.5	33	1.1	0.7-1.8	1.2	0.7-1.8	1.2	0.7-1.8
110-129	6.8	26	10.2	39	0.7	0.4-1.1	0.7	0.4-1.1	0.7	0.4-1.1
130-160	8.9	9	11.1	15	0.8	0.3-1.8	0.8	0.3-1.8	0.8	0.4-2.0
Enlistment Status										
Drafted	10.9	91	11.6	93	0.9	0.7-1.3	0.9	0.7-1.2	0.9	0.7-1.2
Enlisted	7.8	35	9.8	38	0.8	0.5-1.3	0.8	0.5-1.2	0.8	0.5-1.2
Years Between Entry and Birth										
≤5	11.5	45	12.9	50	0.9	0.6-1.3	0.8	0.6-1.3	0.8	0.6-1.3
6-10	10.5	54	10.4	49	1.0	0.7-1.5	1.0	0.7-1.5	1.0	0.7-1.4
11+	7.3	27	9.7	32	0.8	0.4-1.3	0.8	0.4-1.3	0.8	0.5-1.3

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

**Table 27. Number of Children With Reported Birth Defects, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios, by Selected Covariates**

Characteristic (of Veteran)	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	Rate	No. <sup>c</sup>	Rate	No. <sup>c</sup>	OR	95% CI	Model 1 <sup>a</sup>	95% CI	Model 2 <sup>b</sup>	95% CI
Age at Birth of Child										
≤25	66.4	280	44.2	170	1.5	1.3-1.9	1.5	1.2-1.8	1.5	1.2-1.8
26-30	70.8	355	54.1	253	1.3	1.1-1.6	1.3	1.1-1.5	1.3	1.1-1.5
31+	53.8	191	49.3	167	1.1	0.9-1.4	1.1	0.9-1.3	1.0	0.8-1.3
Race										
White	69.4	719	51.8	493	1.4	1.2-1.5	1.3	1.2-1.5	1.3	1.2-1.5
Black	50.7	78	39.3	56	1.3	0.9-1.9	1.2	0.9-1.8	1.1	0.8-1.6
Hispanic and other	32.3	29	42.5	41	0.8	0.5-1.2	0.7	0.5-1.2	0.7	0.4-1.2
General Technical (GT) Test Score										
40-89	57.7	196	50.8	140	1.1	0.9-1.4	1.1	0.9-1.4	1.1	0.9-1.3
90-109	67.1	291	47.5	185	1.4	1.2-1.7	1.4	1.1-1.7	1.3	1.1-1.6
110-129	66.8	257	50.7	194	1.3	1.1-1.6	1.3	1.1-1.6	1.3	1.1-1.6
130-160	71.0	72	48.3	65	1.5	1.1-2.1	1.5	1.0-2.1	1.4	1.0-2.0
Enlistment Status										
Drafted	65.2	542	48.8	392	1.4	1.2-1.6	1.3	1.2-1.5	1.3	1.1-1.5
Enlisted	63.5	284	51.1	198	1.3	1.0-1.5	1.2	1.0-1.5	1.2	1.0-1.5
Years Between Entry and Birth <sup>d</sup>										
≤2	68.6	29	46.1	36	1.5	0.9-2.5	1.5	0.9-2.4	1.4	0.8-2.3
3-5	67.5	236	44.9	139	1.5	1.2-1.9	1.5	1.2-1.9	1.5	1.2-1.9
6-10	68.3	353	51.8	245	1.3	1.1-1.6	1.3	1.1-1.5	1.3	1.1-1.5
11+	56.2	208	51.5	170	1.1	0.9-1.4	1.1	0.9-1.3	1.0	0.8-1.3

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> This covariate has been divided into more categories for the purpose of subgroup analyses.

Vietnam (*i.e.*, male Army enlisted personnel with one term of service) and, at the same time, made it possible to maximize the similarity of the comparison group. Although we may never fully understand how men were chosen for duty in Vietnam (versus other locations), the selection criteria used here probably yielded the highest degree of comparability between "exposed" and "nonexposed" groups possible in an observational study such as this. A comparison of military-service and interview characteristics for the two groups of veterans has confirmed their general similarity; adjustment for these characteristics made little or no difference in the results of the analysis of most outcomes. In addition, further restriction of the comparison groups to men who had served foreign tours other than Vietnam did not affect the results.

Another strength of the study is the use of random samples of Vietnam and non-Vietnam veterans and the avoidance of self-selected groups of veterans. Furthermore, the sample sizes were large enough to detect (with 80% power) an increased risk as small as 40% for child health outcomes occurring at a prevalence of 1% or more. Twofold excesses could be detected for outcomes with a prevalence of 0.2% or greater.

The participation rate was high and of similar magnitude for Vietnam (87%) and non-Vietnam (84%) veterans. In relation to other interview studies, the response rate was exceptional and was probably due to the heightened publicity surrounding issues involving

the health of Vietnam-era veterans, the veterans' concern and their cooperative attitude, and our contractors' intensive efforts to locate and contact veterans.

Although nonrespondents did differ from respondents with respect to certain demographic and military characteristics that may be associated with health status, these differences prevailed in both cohorts and were similar in magnitude (see Volume II). Thus, Vietnam nonrespondents differed no more from their respondent peers than nonrespondents who served elsewhere. These data suggest that excluding veterans who were never interviewed was not likely to have seriously biased the results unless the nonparticipant group was proportionately larger in one of the cohorts, and it was not.

## 4.2 VALIDITY OF DATA

### 4.2.1 Information From Military Records

Information collected from military personnel records and used in most of the analyses included place of service (duty location), date of veteran's birth, year of enlistment, enlistment status (drafted, volunteered), primary military occupational specialty (MOS), and score on the General Technical (GT) test taken at induction. Since military records were considered the official source of data documenting key events in a veteran's military life, we accepted them as a valid source of data.

The primary variable for the purpose of the VES is the "exposure" variable, place of service (Vietnam, non-Vietnam). During the interview, 15 men whom we had classified as

**Table 28. Number of Children With Reported *Serious Health Problems*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios, by Selected Covariates**

Characteristic (of Veteran)	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	Rate	No. <sup>c</sup>	Rate	No. <sup>c</sup>	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Age at Birth of Child										
≤25	150.0	625	128.1	485	1.2	1.1-1.4	1.2	1.1-1.4	1.2	1.1-1.4
26-30	173.9	864	135.7	629	1.3	1.2-1.5	1.3	1.2-1.5	1.3	1.2-1.5
31+	148.1	522	124.6	418	1.2	1.1-1.4	1.2	1.1-1.4	1.2	1.0-1.4
Race										
White	162.6	1668	134.1	1264	1.3	1.2-1.4	1.3	1.2-1.4	1.3	1.2-1.4
Black	145.3	220	126.0	176	1.2	1.0-1.5	1.2	0.9-1.5	1.2	1.0-1.5
Hispanic and other	138.7	123	96.3	92	1.5	1.1-2.0	1.5	1.1-2.0	1.5	1.1-2.0
General Technical (GT) Test Score										
40-89	158.7	531	122.6	332	1.4	1.2-1.6	1.3	1.2-1.6	1.3	1.2-1.6
90-109	162.0	696	120.7	466	1.4	1.2-1.6	1.4	1.2-1.6	1.4	1.2-1.6
110-129	160.6	614	142.9	541	1.1	1.0-1.3	1.1	1.0-1.3	1.1	1.0-1.3
130-160	142.3	143	132.9	177	1.1	0.9-1.4	1.1	0.9-1.4	1.1	0.8-1.3
Enlistment Status										
Drafted	156.7	1289	129.8	1030	1.2	1.1-1.4	1.2	1.1-1.4	1.2	1.1-1.3
Enlisted	162.9	722	130.8	502	1.3	1.1-1.5	1.3	1.2-1.5	1.3	1.2-1.5
Years Between Entry and Birth										
≤5	150.0	581	122.4	468	1.3	1.1-1.4	1.3	1.1-1.5	1.3	1.1-1.5
6-10	170.2	870	142.9	669	1.2	1.1-1.4	1.2	1.1-1.4	1.2	1.1-1.4
11+	152.4	560	120.8	395	1.3	1.1-1.5	1.3	1.1-1.5	1.3	1.1-1.5

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.



**Table 29. Number of Reported *Infant Deaths*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios, by Selected Covariates**

Characteristic (of Veteran)	Vietnam		Non-Vietnam		Crude Results		Multivariate Results			
	Rate	No. <sup>c</sup>	Rate	No. <sup>c</sup>	OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
							OR	95% CI	OR	95% CI
Age at Birth of Child										
≤25	17.3	72	13.5	51	1.3	0.9-1.8	1.2	0.8-1.8	1.2	0.8-1.8
26-30	9.5	47	13.4	62	0.7	0.5-1.0	0.7	0.5-1.1	0.8	0.5-1.1
31+	9.4	33	7.7	26	1.2	0.7-2.0	1.1	0.6-1.8	1.1	0.6-1.8
Race										
White	12.3	126	10.4	98	1.2	0.9-1.5	1.1	0.9-1.5	1.1	0.9-1.5
Black	9.9	15	17.2	24	0.6	0.3-1.1	0.6	0.3-1.1	0.6	0.3-1.1
Hispanic and other	12.4	11	17.8	17	0.7	0.3-1.5	0.7	0.3-1.5	0.7	0.3-1.5
General Technical (GT) Test Score										
40-89	14.3	48	15.1	41	0.9	0.6-1.4	0.9	0.6-1.4	0.9	0.6-1.4
90-109	11.2	48	10.6	41	1.1	0.7-1.6	1.0	0.7-1.6	1.1	0.7-1.7
110-129	11.3	43	11.6	44	1.0	0.6-1.5	0.9	0.6-1.5	1.0	0.6-1.5
130-160	8.0	8	6.8	9	1.2	0.5-3.1	1.2	0.4-3.1	1.0	0.4-2.8
Enlistment Status										
Drafted	10.6	87	13.0	103	0.8	0.6-1.1	0.8	0.6-1.1	0.8	0.6-1.0
Enlisted	14.7	65	9.4	36	1.6	1.0-2.4	1.5	1.0-2.3	1.7	1.1-2.6
Years Between Entry and Birth										
≤5	17.3	67	15.2	58	1.1	0.8-1.6	1.1	0.8-1.6	1.1	0.8-1.6
6-10	10.0	51	11.7	55	0.8	0.6-1.2	0.8	0.6-1.2	0.9	0.6-1.3
11+	9.3	34	8.0	26	1.2	0.7-1.9	1.1	0.6-1.8	1.1	0.6-1.8

<sup>a</sup> Model 1 contains the primary covariates.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

Vietnam veterans denied that they had ever served there, and 15 other men whom we had classified as non-Vietnam veterans mentioned that they **had** served in Vietnam. This degree of misclassification (0.2%) is, however, minimal and is not likely to have had any appreciable effect on our estimates of differential risk. More problematic than the classification of exposure status is the actual definition of exposure. Vietnam service represents a large set of experiences that may not be homogeneous among veterans who served there.

#### 4.2.2 Information From the Interview

Information obtained from the interview and used in many analyses included race, education, cigarette smoking habits, alcohol use, marital status, illicit drug use in the Army, and date of child's birth or pregnancy outcome. Missing values for these variables were minimal. Furthermore, the proportion of missing values was similar for Vietnam and non-Vietnam veterans.

Most of the above variables are relatively simple items and should have been easily understood by almost all veterans. Although respondents may have had more difficulty in recalling information such as the average number of cigarettes smoked per day and the average number of alcoholic drinks per month, we grouped individual values into a few

broad categories for analysis, thus reducing the possible effect of misclassification. Further, there is no compelling reason to suspect that place of service would exert a strong effect on response for these types of variables.

Information collected on use of illicit drugs while in the Army, frequency of various combat experiences, and perceived exposure to herbicides in Vietnam may be more problematic. Although the level of "Don't know" and "Refused" responses for illicit drug use was relatively low (Volume II), the possibility that some users said "No" cannot be dismissed. Although the self-reported level of combat exposure may not be an entirely valid measure of this component of the Vietnam experience, it was found to be related to other indicators of the potential for combat that were derived from military records (Volume II). Self-reported exposure to herbicides in Vietnam was never intended to serve as a proxy measure of actual exposure; it was intended to be an indicator of veterans' perceptions of their possible exposure, given the existing level of concern about this issue (Holden, 1979).

**Table 30. Number of Reported Miscarriages, Crude Rates Per 100 Total Pregnancies Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios for Children of Vietnam Veterans, by Component of Vietnam Experience**

Experience	Rate	No. <sup>c</sup>	Multivariate Results					
			Crude Results		Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
			OR	95% CI	OR	95% CI	OR	95% CI
<u>Non-Vietnam</u>								
	8.7	1190	—	—	—	—	—	—
<u>Vietnam</u>								
Reported Combat Exposure <sup>d</sup>								
Low	9.0	320	1.0	—	1.0	—	1.0	—
Mid	10.0	356	1.1	1.0-1.3	1.1	0.9-1.3	1.1	0.9-1.3
High	11.0	379	1.3	1.1-1.5	1.2	1.0-1.4	1.2	1.0-1.4
Very high	11.6	463	1.3	1.1-1.5	1.2	1.0-1.5	1.2	1.0-1.4
Reported Drug Use in Army								
None	10.1	1096	1.0	—	1.0	—	1.0	—
Marijuana only	11.1	307	1.1	1.0-1.3	1.1	0.9-1.3	1.0	0.9-1.2
Hard drugs	11.8	156	1.2	1.0-1.4	1.1	0.9-1.3	1.0	0.8-1.2
Reported Herbicide Exposure <sup>d</sup>								
None	8.8	552	1.0	—	1.0	—	1.0	—
Low	10.6	489	1.2	1.1-1.4	1.2	1.0-1.4	1.2	1.0-1.4
Mid	12.3	406	1.5	1.3-1.7	1.4	1.2-1.6	1.4	1.2-1.6
High	14.8	113	1.8	1.5-2.3	1.7	1.3-2.1	1.7	1.3-2.1
Year of Entry into Army								
1965-66	10.8	567	1.0	—	1.0	—	1.0	—
1967-69	10.0	840	0.9	0.8-1.0	0.9	0.8-1.0	0.9	0.8-1.0
1970-71	12.1	159	1.1	0.9-1.4	1.1	0.9-1.4	1.1	0.9-1.4
Primary Military Occupational Specialty								
Nontactical	10.5	1020	1.0	—	1.0	—	1.0	—
Tactical	10.3	546	1.0	0.9-1.1	1.0	0.8-1.1	1.0	0.8-1.1

<sup>a</sup> Model 1 contains the primary covariates. Each multivariate result is also adjusted for the other components of the Vietnam experience. No interactions were assessed.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> See Volume II, Appendix E, for methods used to create combat and herbicide exposure indices.

**Table 31. Number of Reported Stillbirths, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios for Children of Vietnam Veterans, by Component of Vietnam Experience**

Experience	Rate	No. <sup>c</sup>	Multivariate Results					
			Crude Results		Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
			OR	95% CI	OR	95% CI	OR	95% CI
			<u>Non-Vietnam</u>					
	11.0	131	—	—	—	—	—	—
			<u>Vietnam</u>					
Reported Combat Exposure <sup>d</sup>								
Low	10.0	31	1.0	—	1.0	—	1.0	—
Mid	8.8	27	0.9	0.5-1.5	0.9	0.5-1.5	0.9	0.5-1.5
High	7.6	22	0.8	0.4-1.3	0.7	0.4-1.3	0.7	0.4-1.3
Very high	12.3	41	1.2	0.8-2.0	1.1	0.6-1.8	1.1	0.6-1.9
Reported Drug Use in Army								
None	10.3	97	1.0	—	1.0	—	1.0	—
Marijuana only	7.0	16	0.7	0.4-1.2	0.6	0.3-1.0	0.6	0.3-1.0
Hard drugs	12.9	13	1.3	0.7-2.2	1.2	0.7-2.3	1.2	0.7-2.3
Reported Herbicide Exposure <sup>d</sup>								
None	9.0	50	1.0	—	1.0	—	1.0	—
Low	10.6	41	1.2	0.8-1.8	1.1	0.7-1.7	1.1	0.7-1.7
Mid	11.7	32	1.3	0.8-2.0	1.2	0.7-1.9	1.2	0.7-1.9
High	4.9	3	0.5	0.2-1.7	0.5	0.2-1.6	0.5	0.2-1.7
Year of Entry into Army								
1965-66	9.7	44	1.0	—	1.0	—	1.0	—
1967-69	10.2	73	1.1	0.7-1.5	1.2	0.8-1.8	1.2	0.8-1.8
1970-71	8.3	9	0.8	0.4-1.7	0.9	0.4-2.0	1.0	0.5-2.1
Primary Military Occupational Specialty								
Nontactical	8.8	73	1.0	—	1.0	—	1.0	—
Tactical	11.7	53	1.3	0.9-1.9	1.2	0.8-1.8	1.2	0.8-1.8

<sup>a</sup> Model 1 contains the primary covariates. Each multivariate result is also adjusted for the other components of the Vietnam experience. No interactions were assessed.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> See Volume II, Appendix E, for methods used to create combat and herbicide exposure indices.

#### 4.2.3 Unmeasured Characteristics

All covariates used in the analyses of reproductive and child health outcomes pertain to the veteran. These covariates may influence the veterans' perceptions and consequent reporting of outcomes, and they may have been associated with different military experiences or different probabilities of assignment to Vietnam. There is, however, little evidence to support a direct association between these paternal characteristics and reproductive and child health outcomes. Consequently, one limitation of this study is the lack of data about the mothers of the children studied. Maternal behaviors and exposures may be important for a more complete assessment of the outcomes studied. However, given the similarity of sociodemographic and behavioral characteristics between the fathers in the two cohorts, it seems unlikely that maternal characteristics would differ greatly.

#### 4.2.4 Health Outcomes

Perhaps the most serious concern about the results from the VES interview is the quality of information on reproductive and child health outcomes. Data collected in an interview are subjective and rely on selective attention, awareness, and recall on the part of each veteran.

**Table 32. Number of Children With Reported *Birth Defects*, Crude Rates Per 1000 Total Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios for Children of Vietnam Veterans, by Component of Vietnam Experience**

Experience	Rate	No. <sup>c</sup>	Multivariate Results					
			Crude Results		Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
			OR	95% CI	OR	95% CI	OR	95% CI
			<u>Non-Vietnam</u>					
	49.5	590	—	—	—	—	—	—
			<u>Vietnam</u>					
Reported Combat Exposure <sup>d</sup>								
Low	59.1	184	1.0	—	1.0	—	1.0	—
Mid	68.2	209	1.2	0.9-1.4	1.0	0.8-1.2	1.0	0.8-1.2
High	62.3	181	1.1	0.9-1.3	0.9	0.7-1.1	0.9	0.7-1.1
Very high	67.8	226	1.2	0.9-1.4	0.9	0.7-1.1	0.9	0.7-1.1
Reported Drug Use in Army								
None	63.6	600	1.0	—	1.0	—	1.0	—
Marijuana only	63.7	145	1.0	0.8-1.2	1.0	0.8-1.2	1.0	0.8-1.2
Hard drugs	77.2	78	1.2	1.0-1.6	1.2	0.9-1.6	1.2	0.9-1.6
Reported Herbicide Exposure <sup>d</sup>								
None	49.1	272	1.0	—	1.0	—	1.0	—
Low	69.1	268	1.4	1.2-1.7	1.5	1.2-1.8	1.5	1.2-1.8
Mid	87.0	237	1.8	1.5-2.2	2.0	1.6-2.4	1.9	1.6-2.4
High	75.2	46	1.6	1.1-2.2	1.7	1.2-2.4	1.7	1.2-2.4
Year of Entry into Army								
1965-66	62.4	283	1.0	—	1.0	—	1.0	—
1967-69	65.9	472	1.1	0.9-1.2	1.1	0.9-1.3	1.1	0.9-1.2
1970-71	65.1	71	1.1	0.8-1.4	1.0	0.8-1.4	1.0	0.8-1.3
Primary Military Occupational Specialty								
Nontactical	64.6	533	1.0	—	1.0	—	1.0	—
Tactical	64.6	293	1.0	0.9-1.1	1.0	0.8-1.2	1.0	0.8-1.2

<sup>a</sup> Model 1 contains the primary covariates. Each multivariate result is also adjusted for the other components of the Vietnam experience. No interactions were assessed.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> See Volume II, Appendix E, for methods used to create combat and herbicide exposure indices.

For the many reproductive and child health outcomes (other than birth defects, Part B) examined in the interview, verification on this large sample using objective data sources was not feasible. What is most important here is not so much absolute validity *within* a group of veterans, but whether outcome data obtained from one group of veterans are any more (or less) valid than those from the other group. We acknowledge the possibility of information bias in this study. Possible explanations for increased reporting among Vietnam veterans include the following:

- (1) **Differential medical care utilization.** Vietnam veterans may have been more health-conscious and may have taken their children to doctors more often than non-Vietnam veterans.
- (2) **Differential recall of health outcomes.** Vietnam veterans may have a heightened sense of recall because of their unique war experience and the extensive media attention given them since at least 1978.
- (3) **A class action lawsuit against the makers of Agent Orange.** A suit brought in 1979 by thousands of Vietnam veterans against manufacturers of Agent Orange may have

influenced the responses of Vietnam veterans. The suit claimed that exposure to the herbicide in Vietnam caused health problems for the veterans and their families. In May 1984 (about 1 year before interviewing for the VES began), an out-of-court settlement was reached in which the seven chemical companies agreed to create a \$180 million fund for affected veterans and their families (Fox, 1984). The prospect of financial remuneration for health problems could have been an incentive for Vietnam veterans to report any altered state of health (however slight) when questioned in detail in our interview.

- (4) **Attitudinal factors.** Vietnam veterans may have reported a variety of reproductive and child health outcomes more frequently than other veterans as a way of expressing various complaints they have had since their military duty.

Unfortunately, it is next to impossible to quantify the individual or combined influence of these factors on the results reported here.

**Table 33. Number of Children With Reported *Serious Health Problems*, Crude Rates Per 1000 Live Births Among Vietnam and Non-Vietnam Veterans, and Crude and Adjusted Odds Ratios for Children of Vietnam Veterans, by Component of Vietnam Experience**

Experience	Rate	No. <sup>c</sup>	Crude Results		Multivariate Results			
			OR	95% CI	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>	
					OR	95% CI	OR	95% CI
			<u>Non-Vietnam</u>					
	130.1	1532	—	—	—	—	—	—
			<u>Vietnam</u>					
Reported Combat Exposure <sup>d</sup>								
Low	149.0	459	1.0	—	1.0	—	1.0	—
Mid	151.0	459	1.0	0.9-1.2	0.9	0.8-1.1	0.9	0.8-1.1
High	163.4	471	1.1	1.0-1.3	1.0	0.8-1.1	0.9	0.8-1.1
Very high	173.1	570	1.2	1.0-1.4	1.0	0.8-1.1	1.0	0.8-1.1
Reported Drug Use in Army								
None	160.6	1499	1.0	—	1.0	—	1.0	—
Marijuana only	145.6	329	0.9	0.8-1.0	0.9	0.8-1.0	0.8	0.7-0.9
Hard drugs	171.9	171	1.1	0.9-1.3	1.0	0.8-1.1	0.9	0.7-1.1
Reported Herbicide Exposure <sup>d</sup>								
None	125.2	688	1.0	—	1.0	—	1.0	—
Low	173.0	664	1.5	1.3-1.6	1.6	1.4-1.8	1.5	1.3-1.7
Mid	197.5	532	1.7	1.5-1.9	1.8	1.6-2.0	1.7	1.5-2.0
High	201.0	122	1.8	1.4-2.2	1.7	1.3-2.1	1.7	1.4-2.2
Year of Entry into Army								
1965-66	151.9	682	1.0	—	1.0	—	1.0	—
1967-69	163.9	1162	1.1	1.0-1.2	1.1	1.0-1.2	1.1	1.0-1.3
1970-71	154.5	167	1.0	0.8-1.2	1.1	0.9-1.3	1.1	0.9-1.3
Primary Military Occupational Specialty								
Nontactical	162.1	1325	1.0	—	1.0	—	1.0	—
Tactical	153.0	686	0.9	0.8-1.0	0.9	0.8-1.0	0.9	0.8-1.0

<sup>a</sup> Model 1 contains the primary covariates. Each multivariate result is also adjusted for the other components of the Vietnam experience. No interactions were assessed.

<sup>b</sup> Model 2 contains the primary and secondary covariates.

<sup>c</sup> Sum of cases over strata may be less than total numbers presented in previous analyses because of missing values for covariates.

<sup>d</sup> See Volume II, Appendix E, for methods used to create combat and herbicide exposure indices.