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Department of Health, Education and Welfare
Public Health Service Communicable Disease Center

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A Summary of Data On Cases of Poliomyelitis Occurring in Association With Cutter Vaccine

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All readers should be cautioned regarding the limitations of the data presented herein. Current and cumulative data are given concerning reported cases of poliomyelitis in Cutter vaccinees and their familial and community contacts. It should be recognized that these data do not constitute a controlled study, and that interpretations and conclusions based on material in this summary must be guarded.

This presentation has been made possible by the cooperation of local and State Health Departments; personnel of the Communicable Disease Center; federal, State, academic, and private laboratories; The National Institutes of Health, the Vaccine Activities Section, BSS, USPHS; and the National Foundation for Infantile Paralysis, who have generously contributed reports to the Polio Surveillance Unit. Special thanks are due to Dr. David Bodian, Poliomyelitis Laboratory, The Johns Hopkins University, for permission to include the experimental data which appear in Tables 10, 11, 12 and 13.

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October, 1955

Introductory Note

In the spring of 1955 the occurrence of a number of cases of poliomyelitis among recently vaccinated individuals and their contacts presented a problem which raised many questions of importance in the field of poliomyelitis. A definitive account of this problem should eventually be prepared as a reference document. It was felt that an interim summary would be useful at this time (October, 1955), but that detailed discussion of the data might appropriately be deferred. For this reason, the material presented in this summary appears in simple tabular form without additional comment.

The following points must be kept in mind when examining the data: 1) results of 60 day physio-therapy muscle gradings are not included; 2) laboratory data on many cases are incomplete, and; 3) a small number of additional cases may also be accepted in the future on the basis of these laboratory and physio-therapy examinations. It is also expected that many minor corrections in the data herein reported will eventually be made.

This summary includes all cases which may have been "accepted" by the Polio Surveillance Unit through October 21, 1955. "Accepted" cases meet the following criteria:

1) All cases have been classified as bona fide polio by the Polio Reporting Officer submitting the case.
2) Minimum essential data (county residence, age, sex, date of inoculation, date of onset, paralytic status and manufacturer of vaccine used) have been included in the report submitted.

It should be noted that for the purposes of this presentation cases used in the tabulations were selected in the following way:

1) Vaccinated Cases: all cases included had onsets before June 1, 1955, so that no cases with onsets more than 50 days after inoculation are included.
2) Family Contact Cases: all cases included had onsets before June 15, 1955, so that no cases with onsets more than 65 days after inoculation of the vaccinated contact are included.
3) Community Contact Cases: all PSU accepted Community Contact Cases are included without restriction as to date of onset. However, reporting of Community Contact Cases was discontinued on August 1, 1955.

Tabulations of laboratory data are limited to reports of virus isolations from patients, and from household contacts or vaccinated contacts of the patients. At the present time reports on negative stool specimens and on isolations of viruses other than polio virus have not been completely checked and are therefore not presented.

Contents

Table 1

Cutter Associated Poliomyelitis Cases by State
With Paralytic Status and Deaths

	Vaccinated Cases				Family Contact Cases				Community Contact Cases				Totals			
	P*	NP*	T*	D*	P	NP	T	D*	P	NP	T	D*	P	NP	T	D*
Alabama									1		1	1	1		1	1
Arizona	1	1	2			3	3						1	4	5	
California	27	11	38		28	10	38		2	1	3	1	57	22	79	1
Colorado	1		1		2		2						3		3	
Connecticut		1	1											1	1	
Georgia	1		1		3		3	1					4		4	1
T. Hawaii	1		1	1	2		2						3		3	1
Idaho	17	3	20	3	28	8	36	1	4	1	5		49	12	61	3
Illinois	1		1										1		1	
Louisiana	1		1	1	1		1						2		2	1
Maryland					1		1		4	1	5		5	1	6	
Minnesota									1		1		1		1	
Missouri	1		1										1		1	
Montana					1		1	1					1		1	
Nevada	3	1	4		4	1	5						7	2	9	
New Mexico					2	1	3						2	1	3	
New York		1	1											1	1	
Ohio	1		1		1		1	1					2		2	
Oregon	3		3		3	1	4		1		1		7	1	8	
Tennessee					1		1						1		1	
Texas	1		1		1		1						2		2	
Virginia									1		1		1		1	
Washington	1		1		2	1	3		3		3		6	1	7	
Wyoming	1		1										1		1	
Totals	61	18	79	5	80	25	105	4	17	3	20	2	158	46	204	11
% Paralytic			77				76				85				77	
Case Fatality Rate (%)			6				5				10				5	

* P - Paralytic, NP- non-paralytic, T - Total, and D - deaths. Deaths are also tabulated under paralytic cases.

Table 2

Cutter Associated Poliomyelitis Cases
by Date of Vaccination*

Date		VC*	FCC*	CCC*	Totals	
Tues.	April 12		2		2	
Wed.	13	1		1	2	
Thurs.	14	4	2	1	7	
Fri.	15	2	2	6	10	
Sat.	16	7	15	1	23	
Sub totals						44
Sun.	17	4			4	
Mon.	18	10	11	1	22	
Tues.	19	16	23	3	42	
Wed.	20	9	16	1	26	
Thurs.	21	9	5	2	16	
Fri.	22	6	9		15	
Sat.	23	1			1	
Sub totals						126
Sun.	24		1	1	2	
Mon.	25	2	2		4	
Tues.	26	4	6		10	
Wed.	27	2	3		5	
Thurs.	28	1			1	
Fri.	29	1		1	2	
Sub totals						24
Data Incomplete			8	2		10
Totals		79	105	20		204

* VC-vaccinated cases, FCC-family contact cases, CCC-community contact cases. Family and Community contact cases are listed by inoculation date of vaccinated contact.

Table 3

Cutter Associated Poliomyelitis Cases
by Date of First Symptoms

	VC*			FCC*			CCC*			Totals		
	P*	NP*	T*	P	NP	T	P	NP	T	P	NP	T
April 20	2		2							2		2
21	5		5							5		5
22	2	2	4	1		1				3	2	5
23	3		3							3		3
24	3	1	4							3	1	4
25	8		8	1		1				9		9
26	6		6							6		6
27	8	1	9							8	1	9
28	3		3							3		3
29	6	1	7		1	1				6	2	8
30	2		2							2		2
May 1	3	1	4	3	1	4				6	2	8
2	4	4	8	3	1	4				7	5	12
3	1	1	2	2		2				3	1	4
4		2	2	5		5				5	2	7
5		1	1	2		2				2	1	3
6	1		1	4		4				5		5
7	1		1	2		2				3		3
8				4		4	1		1	5		5
9				2	2	4	1	1	2	3	3	6
10				3		3				3		3
11		2	2	2	1	3				2	3	5
12				4	2	6	1		1	5	2	7
13				5	1	6	1		1	6	1	7
14	1	1	2	3	3	6				4	4	8
15				2	1	3				2	1	3
16				2	1	3				2	1	3
17	1		1	2	2	4	1		1	4	2	6
18				6	1	7	1		1	7	1	8
19				1		1	1	1	2	2	1	3
20					1	1					1	1
21				1	1	2	3		3	4	1	5
22				1		1	1		1	2		2
23				4	1	5				4	1	5
24				1		1				1		1
25	1		1				2		2	3		3
26				1		1				1		1
27					1	1	1		1	1	1	2
28				2	1	3				2	1	3

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Table 3 (Continued)

	VC*			FCC*			CCC*			Totals		
	P*	NP*	T	P	NP	T	P	NP	T	P	NP	T
May 29							1		1	1		1
30		1	1	2	1	3				2	2	4
31												
June 1	**			2	2	4				2	2	4
2												
3				1		1		1	1	1	1	2
4				1		1				1		1
5				1		1				1		1
6				1		1				1		1
7												
8												
9				1		1				1		1
10												
11				1		1				1		1
12				1		1				1		1
13												
14												
15				**								
16												
17							1		1	1		1
Totals	61	18	79	80	25	105	17	3	20	158	46	204

Summary By Weeks

Week Ending	VC*			FCC*			CCC*			Totals		
	P*	NP*	T*	P	NP	T	P	NP	T	P	NP	T
April 23	12	2	14	1		1				13	2	15
30	36	3	39	1	1	2				37	4	41
May 7	10	9	19	21	2	23				31	11	42
14	1	3	4	23	9	32	4	1	5	28	13	41
21	1		1	14	7	21	7	1	8	22	8	30
28	1		1	9	3	12	4		4	14	3	17
June 4		1	1	6	3	9	1	1	2	7	5	12
11				5		5				5		5
18							1		1	1		1
Totals	61	18	79	80	25	105	17	3	20	158	46	204

* VC - Vaccinated Cases, FCC - Family Contact Cases, CCC - Community Contact Cases, P - Paralytic, NP - Non-paralytic, and T - total.

** Vaccinated Cases with onsets June 1 or later not included. Family Contact Cases with onset June 15 or later not included.

Table 4

Cutter Associated Poliomyelitis Cases by Interval from Inoculation to First Symptoms**

Interval (Days)	VC*			FCC*			CCC*			Total		
	P*	NP*	T*	P	NP	T	P	NP	T	P	NP	T
1	1		1							1		1
2		1	1	1		1				1	1	2
3	2		2							2		2
4	2		2							2		2
5	12		12							12		12
6	10	2	12							10	2	12
7	12	1	13		1	1				12	2	14
8	5	3	8	1		1				6	3	9
9	5		5							5		5
10	2	2	4	1	1	2				3	3	6
11	2		2							2		2
12	1		1	1		1				2		2
13	2	2	4	3	2	5				5	4	9
14	1		1	3		3				4		4
15		1	1	5		5				5	1	6
16				4		4				4		4
17		1	1	2	1	3				2	2	4
18	1	1	2	2		2	1		1	4	1	5
19		2	2	2		2	1		1	3	2	5
20				3		3				3		3
21		1	1	2	2	4				2	3	5
22	1		1	7	3	10		1	1	8	4	12
23				2	1	3				2	1	3
24				4	4	8	2		2	6	4	10
25	1		1	5		5				6		6
26				3	1	4	1		1	4	1	5
27				2	1	3	2		2	4	1	5
28				3		3				3		3
29												
30				2		2		1	1	2	1	3
31												
32				2	1	3				2	1	3
33							1		1	1		1
34				2	1	3	2		2	4	1	5
35					1	1	1		1	1	1	2
36	1		1	3		3	1		1	5		5
37												
38				1	1	2	1		1	2	1	3
39				1		1	1		1	2		2
40				1		1				1		1
41					1	1	1		1	1	1	2
42				1		1				1		1

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Table 4 Continued

Interval (Days)	VC*			FCC*			CCC*			Totals		
	P*	NP*	T*	P	NP	T	P	NP	T	P	NP	T
43					1	1					1	1
44				1		1				1		1
45				2		2				2		2
46				1		1				1		1
47		1	1								1	1
48				1		1		1	1	1	1	2
Data Incomplete				6	2	8	2		2	8	2	10
Totals	61	18	79	80	25	105	17	3	20	158	46	204

Summary by Weeks

0-3	3	1	4	1		1				4	1	5
4-7	36	3	39		1	1				36	4	40
8-14	18	7	25	9	3	12				27	10	37
15-21	1	6	7	20	3	23	2		2	23	9	32
22-28	2		2	26	10	36	5	1	6	33	11	44
29-35				6	3	9	4	1	5	10	4	14
36-42	1		1	7	2	9	4		4	12	2	14
43-49		1	1	5	1	6		1	1	5	3	8
Data Incomplete				6	2	8	2		2	8	2	10
Totals	61	18	79	80	25	105	17	3	20	158	46	204

*VC-Vaccinated Cases, FCC-Family Contact Cases, CCC-Community Contact Cases, P-Paralytic, NP-Non-paralytic, T-Total.

**Interval between onset of case and date of inoculation of vaccinated contact used for all contact cases.

Table 5

Cutter Associated Poliomyelitis Cases
by Manufacturer's Order Number and Filling Lot Number

Mfr. Order No.	Filling Lot No.	VC*		FCC*		CCC*		All Cases			
		P*	NP*	P	NP	P	NP	P	NP	Totals	
19460											0
	5721									0	
19463											9
	6037	3	3	3				6	3	9	
19467											9
	6038	2	3	3	1			5	4	9	
19468											98
	6039	1		4	1			5	1	6	
	6044	2	2	2		5	1	9	3	12	
	6045	9	1***	4	3	1	1	14	5	19	
	6058	2						2		2	
	?6039 ?6058	15	2	28	8	4	1	47	12	59	
19469											**
19762											6
	5927	1						1		1	
	5928	3	1		1			3	2	5	
19764											40
	5970			2	1			2	1	3	
	5971	7		4		1		12		12	
	5972	8		6	3	1		15	3	18	
	5973	1		2		3		6		6	
	?5971 ?5972			1				1		1	
19766											6
	5974		1						1	1	
	5975										
	5976		2	1	2			1	4	5	
19767											
	5965									**	
	5966									**	
	5967										
Data Incomplete		7***	2	20	5	2		29	7		36
Totals		61	18	80	25	17	3	158	46		204

*VC-Vaccinated Cases, FCC-Family Contact Cases, CCC-Community Contact Cases, P - Paralytic, NP-Non-paralytic. ** These lots were never shipped. ***Includes one case given a second inoculation on day of first symptoms.

Table 6

The Distribution of Cutter Vaccine*
by Manufacturer's Order Number, Filling Lot Number and State

Mfr. Order No.*	Filling Lot No.*	Commercial Inocs.	First Inoculations in NFIP Clinics						Totals
			Ariz.	Cal.	T.H.	Ida.	Nev.	N.M.	
19460	5721			34000					34,000
19463	6037		11000	20000				32000	63,000
19467	6038		2000	48000	3000		4000	4000	61,000
19468	6039				2000	20000	7000	3000	32,000
	6094	19000							19,000
	6045	10000							10,000
	6058				***	12000			12,000
19469	6082								**
	6084								**
19762	5927	13000							13,000
	5928		18000	25000					43,000
19764	5970		***	21000					21,000
	5971	9000							9,000
	5972	11000							11,000
	5973	10000							10,000
19766	5974	13000							13,000
	5975	11000							11,000
	5976		7000	21000	***			12000	40,000
19767	5965								**
	5966								**
	5977			3000	***				3,000
Totals		96000	38000	172000	5000	32000	11000	51000	405,000

*Data for this table courtesy of Vaccine Activities Section, BSS, USPHS.
Sources: Shipments and returns of Cutter vaccine; States' estimates of first inoculations given in NFIP Clinics through May 28, 1955 and tabulated by NFIP.
Mfr. Order No.: Vaccine Lots as produced.
Filling No.: Manufacturer's designation for Distribution Sublots
Commercial Inocs.: Inoculations with vaccine distributed through commercial channels.
Ariz. - Arizona, Cal. - California, T.H. - Territory Hawaii, Ida. - Idaho, Nev. - Nevada, N.M. - New Mexico.

**These lots were never shipped.

*** Less than 500 inoculations.

Table 7

Poliomyelitis Attack Rates
Among Individuals Receiving Cutter Vaccine and Poliomyelitis Attack Ratios
Among Cutter Vaccinees and their Family and Community Contacts

Mfr. Order No.	Prod. No.	No. of Inocs.	Vaccinated Cases: No. of Cases	Vaccinated Cases: Rate per 100,000	Total Associated Cases: No. of Cases	Total Associated Cases: Rate per 100,000
19460	5721	34,000	0	-	0	-
19463	6037	63,000	6	9.6	9	14.3
19467	6038	61,000	5	8.2	9	14.8
19468		73,000	35	48.0	98	132.0
	6039	32,000	1		6	
	6044	19,000	4		12	
	6045	10,000	10		19	
	6058	12,000	2		2	
	?6039) ?6058)		18		58	
19762		56,000	5	8.9	6	10.6
	5927	13,000	1		1	
	5928	43,000	4		5	
19764		51,000	16	31.5	40	78.0
	5970	21,000	0		3	
	5971	9,000	7		12	
	5972	11,000	8		18	
	5973	10,000	1		6	
	?5971) ?5972)				1	
19766		64,000	3	4.7	6	9.4
	5974	13,000	1		1	
	5975	11,000	0		0	
	5976	40,000	2		5	
19767	5977	3,000	0	-	0	-
Data Incomplete			9		36	
Totals		405,000	79	19.5	204	50.4

Table 8

Cutter Associated Poliomyelitis Cases
Virus Isolations by State and Paralytic Status**

	VC*						FCC*						CCC*						Totals					
	P*			NP*			P			NP			P			NP			P			NP		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ala.																								
Ariz.																								
Cal.	15		1	1	1		5			1									20		1	2	1	
Colo.	1						2												3					
Conn.				1																		1		
Ga.	1						3												4					
T.H.																								
Ida.	10			1			23			6			3			1			36			8		
Ill.	1																		1					
La.	1						1												2					
Md.							1						4			1			5			1		
Minn.													1						1					
Mo.																								
Mont.							1												1					
Nev.	2			1			3												5			1		
N.M.																								
NY.																								
Ohio																								
Oreg.	1						3			1			1						5			1		
Tenn.							1												1					
Tex.																								
Va.													1						1					
Wash.										1												1		
Wyo.																								
Total	32	0	1	4	1	0	43	0	0	9	0	0	10	0	0	2	0	0	85	0	1	15	1	0
Isolations		33			5			43			9			10			2			86			16	
			38						52						12						102			
Total Cases			79						105						20						204			

* VC - Vaccinated Cases, FCC - Family Contact Cases, CCC - Community Contact Cases, P - paralytic, NP - non-paralytic; 1,2,and 3 refer to polio virus types.

** Includes all cases in which a virus isolation was reported from the patient and / or household or vaccinated contacts of the patient. Reports of negative attempts at virus isolation are incomplete and are not included.

Table 9

Cutter Associated Poliomyelitis Cases
Virus Isolations by Type of Polio Virus & Paralytic Status*

Polio Virus Isolations	VC*		FCC*		CCC*		Totals	
	P*	NP*	P	NP	P	NP	P	NP
Type I	32	4	43	9	10	2	85	15
Type II		1						1
Type III	1						1	
All Types	33	5	43	9	10	2	86	16
Polio Cases	61	18	80	25	17	3	158	46

* Includes all cases which a virus isolation was reported from the patient and/or household or vaccinated contacts of the patient. Reports of negative attempts at virus isolation are incomplete and are not included.

VC - Vaccinated Cases, FCC - Family Contact Cases, CCC - Community Contact Cases, P - Paralytic, and NP - Non-paralytic.

Table 10

Cutter Associated Poliomyelitis Cases
Paralytic Cases by Date of First Faralysis**
With Predictions Based on Experimental Data

Date	VC*		FCC*		CCC*	
	R*	P*	R*	P*	R*	P*
April 22		0.3				
23	1	0.5				
24	4	1.7				
25	1	1.7				
26	6	2.4				
27	10	2.7				
28	6**	2.9				
29	4	3.8		0.1		
30	2	4.1	1	0.3		
May 1	6	4.1	1**	0.4		
2	4	4.3	2**	0.9		
3	6	4.4		1.0		
4	1	4.4		1.5		
5		4.3	1**	1.8		
6	3	3.0	2	2.2		
7	1	3.0	4	2.9		
8	2	2.5	1	3.2		
9		2.2	4	3.6		
10	1	2.1	3	4.0		
11		1.3	2	4.3		
12		1.0	8	4.6	2	
13		1.0	2**	4.7		
14		0.8	4	4.4		
15		0.6	3	4.4	1	
16		0.3	2	4.2		
17		0.3	2	4.0	1	
18		0.3	6**	3.8	1	
19		0.3	4	3.2	1	
20		0.2	1	2.9		
21	1	0.2	4**	2.7	1**	
22		0.2	2	2.4	1	
23			4**	2.1	1	
24	1			1.7	1	
25			1	1.5		
26				1.3		
27			1	1.2	1	
28				1.0		
29				0.7	4**	
30	1		2	0.7		
31			1	0.5		
June 1			1	0.5		
2				0.3	1	
3			2**	0.2		
4				0.2		

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Table 10 Continued

Date	VC* R*	VC* P*	FCC* R*	FCC* P*	CCC* R*	CCC* P*
June 5			2**	0.1		
6			3	0.1		
7				0.1		
8				0.1		
9				0.1		
10			1			
11						
12			1**			
13						
14			1			
17					1**	
27			1			
	61	61	80	80	17	

Summary by Weeks

Week Ending	VC* R*	VC* P*	FCC* R*	FCC* P*	CCC* R*	CCC* P*
April 23	1	0.8	1			
30	33	19.4	1	0.3		
May 7	21	27.6	10	10.7		
14	3	10.8	24	28.8	2	
21	1	2.2	22	25.3	5	
28	1	0.2	8	11.1	4	
June 4	1		6	3.2	5	
11			6	0.5		
18			2	0.1	1	
25						
July 2			1			
Totals	61	61	80	80	17	

* VC - Vaccinated Cases, FCC - Family Contact Cases, CCC - Community Contact Cases, R - Reported data, P - Predicted cases on the basis of uniform distribution of inoculations, April 16 to 27, and incubation period of inoculation polio in 32 Cynomolgus macaques (Bodian, see Table 11), adjusted to reported totals.

**Includes cases dated by first symptoms in absence of information on date of first paralysis.

Table II

Cutter Vaccinated Poliomyelitis Cases
Paralytic Cases by Interval from Inoculation to First Paralysis
Comparison with Experimental Data, in the Cynomolgus Macaque **

Interval (Days)	Vaccinated Cases No.	%	Monkey Data (Bodian)*** No.	%	Interval (Days)	Vaccinated Cases No.	%	Monkey Data (Bodian)** No.	%
					20				
0					21			1	
1					22				
2					23				
3					24			1	
4	1				25				
		2%							6%
5					26				
6	5		2		27				
7	6		1		28				
8	8		8		29	1			
9	7				30				
		42%		34%			2%		
10	11*		4		31				
11	3		2		32	1			
12	4		1		33				
13	3		6		34				
14	5		2		35				
		42%		47%			2%		
15	1				36				
16	1		1		37				
17			1		38				
18	1		2		39				
19	2				40				
		8%		13%					
					41	1			
							2%		
				Totals		61	100%	32	100%

* Includes one case with a 10 day interval after 1st inoculation and a 3 day interval after 2nd inoculation.

** Data abstracted from David Bodian "Viremia in Experimental Poliomeylitis," American Journal of Hygiene, Vol. 60, page 358, November, 1954. In the experiment cited live Mahoney virus was injected into the right calf of 32 cynomolgus macaques and the incubation period between injection and onset of paralysis recorded.

Table 12

Cutter Vaccinated Poliomyelitis Cases
Paralytic Cases by Site of Inoculation, Site of First Paralysis and Interval between Inoculation and First Paralysis
Comparison with Experimental Data In the Cynomolgus Macaque**

Site of Inoculation	Site of First Paralysis	Interval in Days 0-3	4-7	8-14	15-21	22-28	29-35	36-42	Totals	Monkey Data (Bodian)**
LA	LA		6	19	2				27	23
RA	RA		2	3					5	
LL	LL			2					2	
RL	RL		1	5					6	
Sub Totals									40	23**
Arm	Bulbar			1	2				3	
Arm	Other Arm		2	1	1				4	
Arm	Trunk						1		1	
Arm	Legs		1	5			1	1	8	
Leg	Other Leg			3					3	
Sub totals									19	9**
Data Incomplete				2*					2	
Sub totals									2	
Non-paralytic									18	
Sub totals									18	
Totals			12	41	5		2	1	79	32

* Includes one case tabulated by interval inoculation to first symptoms.

** Dr. David Bodian, Personal communication. Thirty-two Cynomolgus monkeys were inoculated with mahoney virus in the right calf and examined twice daily to determine the site of initial paralysis. All animals were given a 1-ml inoculum drawn from a single virus pool and containing 100 to 1000 tissue-culture doses per ml.

In some cases initial paralysis developed simultaneously in several extremities, including the right leg.

In some cases initial paralysis developed simultaneously in several sites, but in all cases the right leg was not involved at the time when paralysis was first noted.

Table 13

Cutter Vaccinated Paralytic Poliomyelitis Cases
Comparison with Experimental Data in the Cynomolgus Macaque*

Location First Paralysis		Interval Inoculation to First Paralysis (days) 0-3	4-7	8-14	15-21	22	Totals No.	%	Monkey Data* (Bodian) No.	%
in inoculated extremity			9	29	2		40	66%	23	72%
distant from site of (Inoculation)			3	10	3	3	19	31%	9	20%
data incomplete				2			2	3%		
Totals	No.		12	41	5	3	61	100%	32	100%
	%		20%	67%	8%	5%	100%			
Monkey Data (Bodian)*	No.		3	23	5	1	32			
	%		9%	72%	16%	3%	100%			

* See Tables 11 and 12 for references to source.