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ASSESSMENT OF RISK OF HUMAN INFECTION
IN THE MICROBIOLOGICAL LABORATORY

SECOND EDITION

Arnold G. Wedum
Richard H. Kruse

JULY 1969

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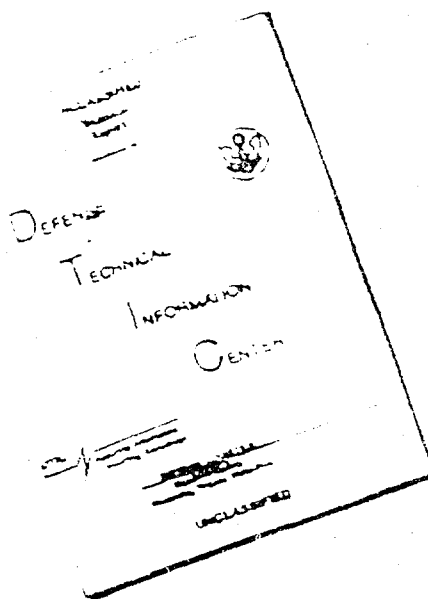
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DEPARTMENT OF THE ARMY
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MISCELLANEOUS PUBLICATION 30

ASSESSMENT OF RISK OF HUMAN INFECTION
IN THE MICROBIOLOGICAL LABORATORY

Second Edition

Arnold G. Wedum

Richard H. Kruse

July 1969

Research and Radiological Division
INDUSTRIAL HEALTH AND SAFETY DIRECTORATE

FOREWORD

This edition supersedes the first edition, Miscellaneous Publication 19, published November 1966. All material in the first edition is included here. Accordingly, the first edition has been recalled.

ACKNOWLEDGMENTS

The authors express their appreciation to the staff members of the following libraries, whose assistance made possible the literature survey for Tables 3 and 4: Technical Library and Walter Reed Army Medical Unit, Fort Detrick; National Library of Medicine and National Institutes of Health, Bethesda, Maryland; and Department of Agriculture, Washington, D.C. Special thanks are due Mrs. Cathryn F. Eaves, Fort Detrick Technical Library, for locating journals and translations, and Mr. Joseph Forrest, National Library of Medicine, for locating innumerable "hard-to-find" foreign journals and double-checking problem references.

We are grateful to the many interested scientists who contributed their unpublished data for Table 4.

Lastly, we are indebted to the personnel of Industrial Health and Safety Directorate for their aid, especially Russell A. Thomas, who rendered valuable assistance in the animal experiments. The highly competent secretarial help of Mrs. Shirley T. Jewell was invaluable in the compilation of this work.

ABSTRACT

In estimating the risk of human infection during research in the microbiological laboratory and in deciding upon appropriate safeguards, it is useful to know the nature of the work in terms of (i) potential accidental microbial aerosol formation and accidental injection, ingestion, cut, and bite; (ii) the number of recorded laboratory infections and their outcome; (iii) the medical prophylactic procedures available; (iv) whether the microorganism is excreted in urine and feces; and (v) whether inoculated animals infect normal cagemate control animals. Detailed tabular summaries with 700 references and working assumptions pertinent to these matters are presented for 162 causative agents or diseases.

CONTENTS

Foreword	2
Acknowledgments	2
Abstract	2
I. INTRODUCTION	5
II. LABORATORY-ACQUIRED HUMAN INFECTION AS AN INDICATOR OF RISK . . .	6
A. Number of Infections	6
B. Infectious Human Dose	6
III. PRESENCE OF THE MICROORGANISM IN URINE AND FECES OF INOCULATED ANIMALS AS AN INDICATOR OF RISK	8
IV. INFECTION OF UNINOCULATED CONTROL ANIMALS CAGED WITH OR NEAR INOCULATED ANIMALS AS AN INDICATOR OF RISK	10
V. TABULAR SUMMATION	12
Literature Cited	13
Distribution List	87
DD Form 1473	89

I. INTRODUCTION

Microbiological safety measures to reduce occupational infection of laboratory personnel have been receiving increased attention.^{1,2,4,5,16} A major problem lies in deciding what is important in laboratory design,^{11,18} equipment, and precautionary technique.¹⁷ Inevitably there are inconsistencies; one important reason is that the precipitating act, source, or means of infection of personnel is unknown in 80 to 84% of laboratory-acquired illnesses.

This publication presents information that will aid in assessing the risk to the experimenter, to the experiment, and to the public that may accompany research on diseases infectious for man, or that may arise during handling, care, and public transportation of infected animals. The Appendix provides much of this information in tabular form with associated citations to the literature. It is as much a purpose of this publication to discourage excessive precautions as it is to encourage caution when knowledgeable evaluation shows a need for protection.

Long experience has provided an answer one way or another in many instances. Yet, with the emerging etiology of various old diseases of man and studies of newly recognized entities, there are now few responsible persons who are willing to await the verdict of time, with its possible repetition of the illnesses and deaths that marked earlier investigations in microbiology. Certainly no one wants to be responsible for a series of illnesses involving those diseases with a long incubation period. One example is the special virus-leukemia program of the National Cancer Institute, which is based upon the assumption that at least one virus is an indispensable element in human leukemia or lymphoma. In this program, concentration of actual or potential causative agents into very small volumes has now been achieved, and cross-species experimental transfer appears imminently possible among chickens, mice, and monkeys.

This report primarily concerns microbial diseases of man. Undoubtedly many references have been missed in compiling Tables 3 and 4. In some instances there are so many reports, such as those for the successful recovery of enteroviruses from human feces, that only the first few references that came to hand are mentioned, without any attempt to recognize priority of publication. Our limited experience in the veterinary field has allowed only incomplete coverage there, but it is sufficient to assist in judging the risk of human infection. In the field of cancer and leukemia, inclusion of the few reports available is intended to stimulate the interest of investigators in providing more information, so that the need for precautionary practices can be better evaluated. Additions and corrections will be welcomed.

II. LABORATORY-ACQUIRED HUMAN INFECTION AS AN INDICATOR OF RISK

A. NUMBER OF INFECTIONS

Table 1 lists 2,912 laboratory-acquired human infections that have been reported in various summaries. Of course, there are many unreported cases, especially among those characterized by a mild illness or by a subclinical infection recognizable only by a serologic change. Not included are many cases among veterinarians infected while handling naturally infected animals and among nurses and physicians in contact with patients. Sometimes it is difficult to decide whether such an illness should be considered laboratory-acquired or not.

A judicious examination of Table 1 requires consideration of how long the disease has been under laboratory study, how many persons have been in laboratory contact, the effectiveness of vaccination, and the extent to which laboratory infections have been recognized and reported.

B. INFECTIOUS HUMAN DOSE

It is not always fully realized that only a small number of appropriate microorganisms are required to induce illness in man. Table 2 summarizes various published data. The indicated human infectious dose produced clinical disease in 50% or more of the volunteers. For such highly infectious microorganisms as Pasteurella tularensis or Coxiella burnetii, ten microbial units are enough to infect most unimmunized men.

The data in Table 2, and many years' experience in reviewing laboratory-acquired human illness in relation to the minimum animal infective dose, have resulted in a working assumption that can be useful in deciding whether a microorganism presents a hazard to man in the laboratory. This assumption is, for diseases known to infect man, that the ID₅₀ for man, monkey, mouse, and guinea pig are all approximately the same in the absence of a naturally acquired animal immunization. Sometimes the minimum dose necessary to produce obvious symptoms is less in man than in laboratory animals.¹⁴ An associated working rule is that exceptions need to be proved by direct or good circumstantial evidence. Another useful concept is that as an infectious agent ceases to be primarily species-specific, decreases its minimum non-human infectious dose, and increases its range of susceptible species, it becomes increasingly hazardous for man.

With these assumptions in mind, a rough estimate can be made concerning the number of microorganisms it is safe to swallow from a pipette, inhale during various manipulations, or receive by accidental bite, cut, or injection. Among the relatively few high-risk agents, many routine techniques¹² produce sufficient aerosolized microbial-bearing particles to infect. Fortunately, the human infective dose for most microorganisms is high, so it requires a recognized accident or gross contamination to cause

clinical disease. For instance, in studies directed toward the viral etiology of human leukemia or cancer, the most frequently used items with major hazards probably would be the hypodermic syringe, pipette, high-speed blender, and centrifuge. The cumulative effect of repeated subinfective doses has not been examined systematically to the best of our knowledge. Statistically significant results would be very difficult to obtain because of the numerous variables, even among litter mates.⁷ Practical experience among microbiologists indicates that for many diseases of man, subinfective doses inhaled daily are neutralized by the body defenses. Whether this will apply to concentrated leukemic materials will not be known for some time.

III. PRESENCE OF THE MICROORGANISM IN URINE AND FECES OF INOCULATED ANIMALS AS AN INDICATOR OF RISK

Animals inoculated with microorganisms pathogenic for man present an ill-defined hazard to the experimenter. In a survey at Fort Detrick,¹⁷ 12% of the animal caretakers had been infected compared with 21% of the scientific personnel.

In 1963, Sulkin and co-workers¹⁸ reported a survey of 2,262 laboratory infections. Included in these were 221 among animal caretakers, janitors, etc. compared with 1,534 in trained scientific personnel, 82 in students, and 87 in clerks, maintenance workers, occasional visitors, and others. Only a few of these infections can be attributed to bites, scratches, or accidents during inoculation. An outstanding example of infection by aerosolized viral-bearing particles from dried urine and feces in cage litter is that (Table 1) of 113 human cases of Soviet hemorrhagic fever after 357 wild mice and voles, which were asymptomatic carriers of the causative virus, had been placed in two small animal rooms in a research institute. Only three of the cases were persons in direct contact with the animals.

It is important to know whether the inoculated microorganism or a somewhat similar one is excreted in urine or feces after inoculation, in order to determine whether the animal facilities are adequate for research on those epizootic diseases of domestic animals for which a veterinary permit from the U.S. Department of Agriculture is required. Each disease and change in an experiment will vary in regard to the emphasis that needs to be placed upon preventing (i) infection of persons caring for animals, cleaning cages, and disposing of dead animals and cage litter; (ii) infection of the scientist-technician observing or handling caged infected animals; (iii) infection of persons in other departments, or of visitors; and (iv) complication of the experiment by uncontrolled variables such as augmenting the dose in inoculated animals or infecting control animals. In some cases, fecal or urinary excretion of microorganisms may require special caging to control dust-borne microbial-bearing particles, and special treatment such as steaming or autoclaving animal cages before removing the animal bedding during cage cleaning.

Table 3 is the result of a literature survey. Each number in the table identifies an associated literature citation. Results after ingestion or oral inoculation have been omitted because of possible excretion of the inoculum without multiplication. Except for man, results based upon recovery from urine or feces of naturally infected animals (not experimentally inoculated) usually have been omitted because neither the condition of the animal nor the method of infection might be comparable to those in the laboratory. Also, except for a few special cases of parenteral inoculation, intestinal diseases have not been included because excretion of the organism in feces of a susceptible animal is a foregone conclusion. No critical evaluation has been made of each reference. It is anticipated that anyone interested in a specific disease will make his own evaluation of the reported presence or absence of the microorganism. It is hoped that active experimenters in diseases for which no report is listed will

make sufficient examinations incidental to the primary purpose of their experiments so that, eventually, missing information for significant diseases and animals will be available. We are informed this would be most helpful in the expanding field of cancer-leukemia research as a guide in developing realistic precautions.

Review of Table 3 indicates that the only safe rule to follow is that precautions appropriate to the disease will be based on the assumption that the inoculated microorganism is excreted. The quantity of infective agent excreted, the time and regularity of excretion, and possible attenuation or potentiation of virulence or viability, are complicating variables. It seems best to assume that failure to recover the organism in urine or feces is valid only for the particular conditions at hand, and that results will vary with the strain of organism, animal, stage and severity of disease, diet, animal housing, sampling, and recovery methods. Among diseases of man, the failure to recover the causative organism of Rift Valley fever, the equine encephalitides, yellow fever, and the rickettsiae is significant. However, scattered positive recoveries among the equine encephalitides and typhus lead one to believe that under some conditions even yellow fever virus could be obtained from urine or feces.

IV. INFECTION OF UNINOCULATED CONTROL ANIMALS CAGED WITH OR NEAR INOCULATED ANIMALS AS AN INDICATOR OF RISK

Table 4 supplements information originally compiled by Wedum.¹⁷ Additional data were obtained from a library review and a subsequent laboratory program designed to supply data for representative significant human diseases. Study of Table 4, the associated Table 3, and the references cited permits some interesting conclusions of value in assessing risk to the experimenter and to the experiment.

As a general rule, an animal that has received a microbial respiratory challenge by exposure either of its whole body or of the head only to microbial aerosol will infect a normal unexposed animal if they are placed in the same clean cage, subject to the following considerations:

- 1) This infection occurs from microorganisms loosed from the fur of the exposed animal and inhaled by the normal cagemate.^a
- 2) Exposure of the head only reduces the chance of infection of the normal cagemate, but avoidance of normal cagemate infection by the technique of head-only exposure can be depended upon only for a proved set of experimental techniques (animal, organism, and microbial aerosol concentration).
- 3) Immediately after exposure to the microbial aerosol, placing the whole-body or head-only exposed animal in a closed cage ventilated by 150 liters of air per minute for 15 minutes, and then housing both animals in a closed cage ventilated at 65 liters per minute cannot be depended upon to prevent normal cagemate infection, except for a proved set of experimental conditions.
- 4) Infection of the normal cagemate usually can be avoided if all the fur on the body or head of an aerosol-exposed animal is forcefully ruffled by a manually manipulated jet of 150 liters of air per minute for 10 minutes^c before the exposed animal and its normal unexposed cagemate are placed in a clean closed cage ventilated at 65 liters of air per minute.
- 5) Even in the absence of the forceful fur-washing technique by airjet, an animal whose whole body is exposed to a microbial aerosol ceases to be infective for a normal cagemate after 4 to 6 days in a closed ventilated cage, in terms of liberation of organisms from the fur.

Among diseases infectious for man, excluding intestinal diseases, presence of the causative agent in the urine and feces of the experimentally inoculated animal usually does not result in infection of normal cagemates, even in solid-bottomed cages. Nevertheless, in these cases precautions appropriate to the disease are necessary for the man who empties the contaminated bedding and cleans the cages, and for the animal caretaker.

As a general rule, among the communicable diseases of man studied in rabbits, small rodents, and monkeys, infection of normal cagemates by injected animals is rather unusual. (Bacterial intestinal infections are omitted from the rule.) Notable exceptions are among the tick-borne mite-borne viral hemorrhagic fevers, louping ill, lymphocytic choriomeningitis, monkey B virus disease, tuberculosis, and, to a lesser extent, poliomyelitis.

Bearing in mind the conditions and limitations of the general rule specified above, infection of normal cagemates is always an important warning of infectious danger to the animal caretaker and to the laboratory personnel working with the agent in animals, eggs, tissue culture, or other growth media. This warning becomes increasingly significant as cannibalism and ingestion of food and water contaminated by urine or feces are reduced or eliminated.

Pen, stall, or cagemate infection is common among many diseases of animals seldom found in man. These present little hazard to the laboratory experimenter.

The experiment must also be protected from uncontrolled variables during animal assay. This includes the standardization of animals, use of specific-pathogen-free (SPF) animals or "germ-free" animals, control of enzootic and epizootic outbreaks, animal diet, housing and care of animals, etc. Infection of normal cagemate control animals by the experimentally inoculated animals is just another aspect of this subject. Whenever infection of normal cagemates appears it deserves attention because it may cause augmentation of the experimental inoculum or otherwise disturb the course of the assay. If it cannot be controlled by a change in caging practices, some alteration in the experimental method may be needed, such as that of caging together only those animals receiving the same dosage of microorganisms.³ Accidental infection or augmentation of dosage may occur through cannibalism, from skin or fur contaminated by the inoculum, from infectious nasal secretion, from infectious respiratory droplet nuclei, from infectious airborne dust originating in animal bedding contaminated by urine and feces, or by ingestion of food or water contaminated by urine, feces, or oral secretions.^{8,13}

V. TABULAR SUMMATION

To aid in evaluating the indicators of risk presented in Tables 2, 3, and 4, the principal features of each table and one added element have been combined in Table 5. It would be useful to have information tabulated by laboratory-acquired disease showing how many of the infections were sub-clinical, mild, severe, or lethal, or to have some other standard such as average days lost from work or average days hospitalized. A detailed examination of frequency rates and severity rates was made by Phillips.¹⁰ Seventh per cent or more of the cases were classified as resulting in no permanent disability, although the range in four summaries was from 31 to 93%. Deaths are included in Table 5 insofar as they are identified by single diseases in the citations. However, there were 107 deaths among the 2,348 cases reported in 1961,¹⁵ and consequently the death rate is no less than 4.5%. Other series have fatality rates of 0.52 to 7.47%.⁹

In connection with column 2 of Table 5, readers will notice the omission of the data on respiratory and oral challenge that appear in Table 4. This omission was based on our findings that infection of a cagemate control animal after aerosol challenge of the test animal usually is due to mechanical transfer of organisms released from the fur of the test animal, and consequently is not a true transfer of the infection from one animal to the other.⁸ Oral challenge likewise is often more of a cross contamination than it is a cross infection. Therefore, the infection of uninoculated cagemates in these instances indicates the hazard of the technique more than it does the hazard of the disease. This conservative view heightens the significance of the few plus signs in column 2 as indicators of risk.

There may be some disagreement with various individual points in Table 5, but it permits each investigator to add his own special knowledge and judge his own situation in the light of information on many other microorganisms.

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TABLE 1. LABORATORY-ACQUIRED HUMAN INFECTIONS

Causative Agent or Disease	Number of Infectious/	Literature Cited
Absettarov virus	1	1
Actinomycosis	3	24
Adenovirus	8	19
Amebiasis	20	24
Anthrax	36	24
Apeu virus	1	6, 10
Avian lymphomatosis	1	3
Bebaru virus	1	2
Blastomycosis	8	8
Brucellosis	274	19
Bunyamwera virus	6	19
Candidiasis	2	19
Chikungunya virus	19	10
Cholera	9	24
Coccidioidomycosis	108	8
Colorado tick fever	8	10
Coxsackie virus	35	19
Dengue	6	10
Dermatophytoses	84	8
Diphtheria	40	24
Eastern equine encephalitis	2	16, 28
ECHO virus	1	20
Erysipelothrix	32	24
Foot-and-mouth disease	2	7, 17
Ganjam virus	2	26
Germiston	3	10, 13
Glanders	14	24
Gonorrhea	4	24
<u>Hemophilus influenzae</u>	7	24
Hepatitis, infectious	126	19
Histoplasmosis	81	8
Hypr virus	4	1
Ilheus virus	1	15, 26
Influenza virus	7	21
Japanese B encephalitis	2	2, 25 ^{b/}
Junin virus	5	10
Kemerovo virus	6/	25
Kunjin virus	2	5, 10
Kyasanur Forest disease	65	10
Leishmaniasis	4	24
Leptospirosis	45	24
Louping ill	21	10
Lymphocytic choriomeningitis	19	19
Lymphogranuloma venereum	6	19
Machupo virus	4	12
Malaria	13	19
Marituba	1	10
Mayaro virus	3	10
Measles	1	21
Meningococcus	5	24
Monkey B virus	11	19, 21
Mucambo virus	2	10
Mumps	3	21
Mycoplasma (PPLO)	1	19
Nairobi sheep disease	1	10
Negishi virus	6/	25

Causative Agent or Disease	Number of Infections ^{a/}	Literature Cited
Newcastle virus	32	19
Nocardiosis	1	19
Omsk hemorrhagic fever	3	10
Oriboca virus	1	10
Oropouche virus	2	10
Ovine dermatitis	5	19
<u>Pasteurella leptiseptica</u>	b/	22
Piry virus	5	26
Plague	4	19
Pneumococcus	4	24
Poliomyelitis	9	19
Powassan virus	1	10
Pseudorabies (Aujeszky's disease)	1	20
Psittacosis	70	19, 21
Q fever	184	19
Rat bite fever	14	19
Relapsing fever	38	24
Rickettsial pox	6	19
Rift Valley fever	24	21
Rio Bravo virus	5	10, 23
Rocky Mountain spotted fever	23	19
Ross River virus	2	2
Russian Far East encephalitis	b/	22
Russian spring-summer encephalitis	5	19
St. Louis encephalitis	1	10
Salmonellosis	54	24
Semliki Forest virus	1	4, 26
<u>Serratia marcescens</u>	4	24
Shigellosis	54	24
Smallpox	1	27
Soviet hemorrhagic fevers	113	14
Spondweni virus	2	10
Sporotrichosis	7	8
Staphylococcus	19	19
Streptococcus	67	24
Tetanus	6	24
Toxoplasmosis	21	19
Trachoma	5	19
<u>Treponema pallidum</u>	10	24
Trypanosomiasis	5	19
Tsutsugamushi (scrub typhus)	12	19
Tuberculosis	174	19
Tularemia	129	19
Typhoid	292	24
Typhus (endemic & epidemic)	82	19
Vaccinia	9	11, 22 ^{b/}
Venezuelan equine encephalitis	118	10
Vesicular stomatitis	54	10, 18
<u>Vibrio fetus</u>	1	19
Viral pneumonia (atypical)	b/	22
Wesselsbron virus	4	10
Western equine encephalitis	6	1
West Nile virus	13	9, 10
Yellow fever	38	10, 21
Zika virus	1	10

a. The number includes reported subclinical infections.

b. Reference does not specify details or how many cases.

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TABLE 2. HUMAN INFECTIONOUS DOSE

Causative Agent and Reference	Method of Inoculation	Growth Medium		Microbial Units per Human Infectious Dose
		Medium	Microbial Units per ml	
Malaria ¹	Intravenous	Blood	4×10^4	10
Q fever ²	Inhalation	Egg yolk	$1 \times 10^{10a/}$	$10a/$
Salmonellosis ⁴	Ingestion	Beef broth	1×10^9	10^6
Scrub typhus ³	Intradermal	Egg yolk	$15 \times 10^3a/$	$3a/$
Syphilis ³	Intradermal	Rabbit testes ^{b/}	36×10^6	57
Tularemia ⁵	Intradermal	Broth	1×10^{10}	10
Tularemia ⁵	Inhalation	Broth	1×10^{10}	10
Venezuelan equine encephalitis ^{6,8}	Subcutaneous	Egg	$33 \times 10^{10a/}$	$1a/$
West Nile fever ⁷	Intramuscular	Mouse brain	$33 \times 10^9a/$	$1a/$

a. In mouse or guinea pig infective units.

b. Centrifuged resuspended preparation.

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TABLE 3. RECOVERY OF SPECIFIC MICROORGANISMS FROM URINE AND FECES OF INFECTED ANIMALS

Causative Agent or Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Adenovirus	Cattle			23,309	
	Chicken			13,203	
	Dog	309		309	
	Man	128,130,109		71,130,100,309,514	
	Monkey	552		61,309	
	Mouse	139,909,366			309
Swine				133	
African swine fever	Swine	83		62	
Aleutian disease	Mink	125,192		125	
Anthrax	Cat			392	
	Cattle			297,471	
	Chicken			392	
	Crow			272	
	Dog			15,392	
	Fox			271	
	Guinea pig	170,191		170,191	
	Horse			72	
	Jackal			33	
	Man	287,288		287,288,289	
	Monkey			115	
	Mouse	10		170	
	Rat			192	
	Sheep			65	
	Swine			65	
	Vulture			251	
Avian lymphomatosis	Chicken			50,51,52	
Bacteriophage	Dog	191,313,362			
	Guinea pig	11		11	
	Mouse	190,313,363		190	
	Rabbit			278	
	Rat	363			
Bittner agent	Mouse		9		9
Botulinum toxin	Guinea pig	263			
	Man	112,262			
	Rabbit	146			
Brucellosis	Cattle	55,215,239,406		55,406	
	Chicken			76	
	Dog	41,275,416	276	275	
	Guinea pig	88,91		88	
	Horse	406,461	180	76,180,406	
	Man	8,76,137,232,406	421	8,76,406	473
	Rabbit	88			
	Rat	42,76,355			43
	Sheep	405,406,436,461		406,461	336
	Swine	122,238,252,415		145	
Cholera	Guinea pig			322	
	Man	322		322	
	Mouse			322	
	Rabbit	322		322	
Coccidioidomycosis	Dog	235		235	381
	Man	21,467,660		19	
	Monkey				208
	Mouse			239	
Coxsackie A	Cattle			63	
	Man			106,177,224,253,438	
	Monkey			252	

Causative Agent .. Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Coxsackie B	Cattle			53	
	Dog	161			
	Man	156,424,425		106,177,224,253,438	
	Mouse	168,300			
Cryptococcosis	Dog	234			234
	Man	30	258		258
	Pigeon			87,228,307	
Cytomegalic inclusion disease	Man	202,247,348,445			
	Mouse	248			248
Dengue	Man		194,379		
Distemper	Dog		119		
	Ferret		124		124
	Mink				124
Eastern equine encephalitis	Chicken			58	
	Crow			182	
	Horse		409		
	Mouse		420	420	
	Pheasant			352	
	Rabbit			468	168
ECHO virus	Chimpanzee			166	
	Dog			117	
	Man			106,224,253,274,438	
	Mouse				14
EDIM virus	Mouse	205		205	
Enterovirus, Avian	Chicken			402	
	Cattle			2,270,452	
	Dog			452	
	Swine			183,184	
Encephalomyocarditis (EMC) virus	Man			9,441	
	Mouse	9,433		9	
	Rat	9	195	9,114	195
	Swine			114	
<u>Ernsackia-chris insidiosa</u>	Swine			212,458	
Foot-and-mouth disease	Cattle	72,359,431,439,441	34	431,441	34,359
	Chicken			264	
	Guinea pig		34		34
	Man			200,331	
	Swine	250	34	250	34
Friend's virus	Mouse	266			266
Glanders	Donkey			47	
	Guinea pig	259			259
	Hamster	259			259
	Horse			47	
	Man			47	
Hepatitis, infectious	Dog	24,326			326
	Man	103,118,435	140,281	103,140,281,308,440	
Herpes simplex	Man	169			
	Monkey	188		188	
	Mouse	360,364,384,397	168		

Causative Agent or Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Histoplasmosis	Bat			201	
	Dog	327	16,79	327,342	36
	Guinea pig	110,333		110	
	Man	62		62,197,376	
Influenza	Dog	3			
	Guinea pig		369		
	Man	470			
	Mouse	384,385,386,388,389,474			
Japanese B encephalitis	Rabbit		369		
	Man	268,374	237	268	134,237
Junin	Mouse	384			
	Guinea pig	78			78
K virus	Man	45			
	Mouse	9,410		9,410	
Lactic dehydrogenase agent	Mouse	75,292,293,294,318		75,292,293,294,318	
Leptospirosis	Cat	99,443			
	Cattle	20,21,23,336,603,448			
	Dog	20,48,236,246,283,465		246	
	Guinea pig	69,165,290,448		164	
	Hamster	226			
	Horse	7,41,231,462,465			
	Man	12,20,165,171,267,312		164	
	Monkey	265			
	Mouse	20,40,187,394,456,462			
	Rat	20,115,164,291,353,462			
	Sheep	20,462			
	Swine	20,21,186,462			
Lymphocytic choriomeningitis	Guinea pig	418			
	Man	9,223,260			
	Monkey	13			
	Mouse	9,131,418,419,441		9,131,441	
Machupo	Cat		442		
	Guinea pig	174			
	Hamster	172,175		175	
	Man	123	173,176	176	173
	Marmoset	442			442
	Mouse-Calomys	172,175		174	
Rabbit	Rabbit	174			
Mammary tumor agent	Mouse		277		277
Marek's disease	Chicken			35	
Measles (rubella)	Man	127			
Meloidosis	Guinea pig	145,259			259
	Hamster	259			259
	Man	237,390		17	
	Rabbit	145			
	Rat	237			
	Sheep	70	71		
Swine	Swine	317			
Moloney leukemogenic virus	Mouse	217,218			
Monkey B virus	Monkey		9		9,161,316
	Rabbit		316		

Causative Agent or Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Mouse hepatitis	Mouse	9,282		9,54,282,347	
Mouse pox	Mouse	9,97,98,384		9,46	
Mumps	Man	207,426,427,428,429			
Mycoplasma	Man	199,213,367		33,199,284	
Newcastle virus	Cat			21	
	Chicken			17,53,215,358	
	Dog	215		215	
	Duck			215	
	Fox	215		215	
	Goose			215	
	Man	215,379		215	
Parainfluenza 5, DA	Turkey				
	Monkey	59			
Plague	Man	237,321,422		91,237,319	
	Rat	237		237	
Psittacosis	Chicken				135
	Chimpanzee			19,151,152,153,251	
	Man	138,417		100,113,150,339,350,459	
	Monkey			66,89,105,153,206	
	Mouse	363			
Polyoma virus	Rat	363			
	Mouse	345,349		345	
Pseudorabies	Swine		245,371		245,371
Psittacosis-ornithosis	Cattle			22	
	Chicken			26,29,181	
	Dog				129
	Man			260	
	Monkey		209	256	209
	Parakeet			163,340	
	Turkey			299	
Q fever	Cat	120			
	Cattle	28,38,49,211,449	57	28,211	158,159,303
	Chicken			398,400	
	Dog		57		
	Guinea pig	302,377,380		377	
	Horse		57		
	Man	56,80,81,269	64,220,378		64
	Mouse	258	377	377	
	Rat	399			
	Sheep	211,222	2,57,454	2,211,222,446,454	221,395
	Suslik	467		467	
Rabies	Hamster		18		
	Man	178			
	Mouse		18		
Reovirus	Cattle		343	163,452	
	Chimpanzee			452	
	Dog			452	
	Man		344	330,344,452	
	Monkey			452	
	Mouse			452	

Causative Agent or Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Rhinovirus	Cattle Horse Man			1,452 423	1 53,407,408
Rift Valley fever	Cattle Goat Man Mouse Sheep		77,85,279 85 77,85,101,237 85,261 77,101		279 85,86
Rinderpest	Cattle Goat Rabbit Sheep	9,132,149,227,786	477 477 477	9,132,149,227,477 477 365 477	
Rubella	Ferret Man Monkey	90 314,357,444		126,143,314 305,306	
Russian spring- summer encephalitis	Horse Man Monkey Mouse Rat	225,382,383 5,170,319,320,373,475 111	10 141,437	320 5,319,320	141
St. Louis encephalitis	Chicken Horse Man		136 136,204		332 74,136 42,136,328,368
Sarcoma (SV-40) virus	Baboon Monkey	16 16		254	
Semliki Forest virus	Hamster				144
Sendai virus	Mouse	410			
<u>Serratia marcescens</u>	Mouse Rat	384 384			
Shigelliosis	Rabbit			94,95	
Smallpox	Man Monkey		84	167	
Soviet hemorrhagic fevers	Man Mouse Rat	116,387 210,387 210,387,466		210 210,466	
Staphylococcal enterotoxin	Rabbit	393		393	
Swine pox	Swine		185		
Teschen	Swine			6	6,142,244,476
Theiler's mouse encephalomyelitis	Mouse			54,301,413	
Teutsugamushi	Man Mouse Rat		68,189 105 105		

Causative Agent or Disease	Animal	Urine		Feces	
		Recovered	Not Recovered	Recovered	Not Recovered
Tuberculosis	Cat	415		4	
	Cattle	92,132		92,132,450,451	
	Chicken			32,92,132,356	
	Dog	28,147,341,415		273,415	
	Guinea pig	109,311,351		109,232,310,311,351	
	Man	60,216,280,354,430		157,295,372	
	Monkey	109		338	
	Mouse	109		109,196	
	Rabbit	109,229,233		109,249	
	Rat			323	
Tularemia	Cattle	416		416	
	Guinea pig			304	
	Man	243			162
	Mouse	108,325		193,325	
	Rabbit	107			
	Sheep	416		416	
	Water buffalo	179			
Typhoid	Chimpanzee			421	
Typhus (endemic)	Cat	219			
	Guinea pig	240,285,323	298		
	Man		432		
	Mouse		298		
	Rat	27,240,285,460	324,464		324,464
Typhus (epidemic)	Guinea pig		298		
	Man		455		455
	Mouse		298		
Vaccinia	Man	37,128,457			
	Mouse	168			
	Rabbit	117			
Venezuelan equine encephalitis	Cotton rat	472		472	
	Guinea pig		335		
	Horse	198	335		198
	Man		375		375
	Mouse	401	296	296,401	
	Rabbit		335		
Western equine encephalitis	Chicken			44,58,332	
	Guinea pig		154,155		154,155
	Horse		136,235		136
	Man		136,204		136
	Monkey				154,255
	Pigeon				453
Yellow fever	Guinea pig		412		412
	Man		102,242,386,396,404		102,404
	Monkey		102,396,404		102,412
	Horse		411,412		412

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Disease or Causative Agent	Aerosol Exposure			Method of Inoculation				Other (ID, IT, Oral, IC, ID, PF, ICat, IO, IL)	Literature Cited
	Whole Body	Head Only	Nose & Mouth	SC	IV	IM			
Adenovirus	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	++IC ₂ /; ++IC ₃ /; ++IC ₄ /	57
African swine fever	-	-	-	-	-	-	-	++IC ₂ /	61
Alafrican disease	-	-	-	-	-	-	-	++IC ₂ /	34
Anthrax	++	++	++	++	++	++	++IC ₂ /; ++IC ₃ /	++IC ₂ /; ++IC ₃ /	33, 34, 120, 121, 122, 123, 124
Aspergillus	-	-	-	-	-	-	-	-	5
Avian lymphomatosis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	15, 16, 20, 21, 22, 23, 24, 25, 26
Botulinum toxin	++	++	++	++	++	++	++IC ₂ /; ++IC ₃ /	++IC ₂ /; ++IC ₃ /	8
Brucellosis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Canine distemper	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Coccidioidomycosis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Eastern equine encephalitis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Epidermal distemper	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Foot-and-mouth disease	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Friend's virus	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Herpes simplex	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Histoplasmosis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Hog cholera	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Infectious bronchitis	-	-	-	-	-	-	-	++IC ₂ /; ++IC ₃ /	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100

Causative Agent of	Animals	Aerosol Exposure				Method of Inoculation					Literature Cited
		Whole Body	Head Only	Nose & Mouth		IP	SC	IV	IM	Other (IN, IT, Oral, IC, ID, PP, ICar, IO, IL)	
Newcastle disease	Chickens	+abc/; 0#btu/	+bd/	-	-	0#b/; +#c/	0#b/; +#c/	-	0#b/; +#c/	0#btu/; 0#b/; +#bc/; +*c/; IT; +*IO, IN, bc/	7, 8, 98, 144, 2/ 116
Ornithosis	Turkeys	-	-	-	-	+	-	-	-	+*IT, Oral; +*bf/	5
Orfoca	Monkeys	-	-	-	-	-	0*	-	-	-	66
Parainfluenza	Hamsters	-	-	-	-	-	-	-	-	0#INbc/ 0#INb/	26
Plague	Guinea pigs	+	-	+	-	0#bc/	0d/; 0#c/	-	0#bc/	+*INc/; 0#INb/; 0#INc/	34, 78, 80, 156, 2/ 41
	Marmosets	-	-	-	-	-	-	-	-	-	80, 156, 2/ 116
	Mice, kangaroo rats	+cs/; 0#bs/	-	+bd/	-	0#b/; +#c/	0#b/; 0d/; +*c/	-	0#bc/	+*INc/; 0#INb/	2/ 96, 97
Pneumonia virus of mice	Monkeys	+	-	-	-	-	-	-	-	+*ITbc/	67, 118
	Mice	-	-	-	-	-	-	-	-	0#INb/; +c1/	167
Poliovirus	Mice	-	-	-	-	-	-	-	-	-	27, 43, 68, 2/ 122
	Monkeys, chimpanzee	0#bs/	-	-	-	-	0#c/	-	0#c/	+*ICdg/ +IN, Oral bd/	128
Polyoma disease	Hamsters	-	-	-	-	-	0#c/	-	-	-	143
	Mice	-	-	-	-	-	+dp/	-	-	+d1/	
Pseudorabies	Guinea pigs, mice, rabbits, rats, swine	-	-	-	-	-	+	-	+	0cd/	
Psittacosis	Chickens	-	-	-	-	-	-	-	-	-	10
	Mice	0#s/	-	-	-	-	-	-	-	0 Oral d/ 0#ICbc/	126, 2/ 2/
	Monkeys	+*abc/	+*abc/	-	-	0#bc/	0#c/	-	0#c/	-	52
Q fever	Cats	-	-	-	-	-	+	-	-	-	2/ 89, 2/ 1
	Guinea pigs	+	-	+	-	0#bc/	0#bc/	-	0#bc/	0#INbc/	2/
	Hamsters	-	-	-	-	0#bc/	-	-	-	-	
	Monkeys	+*abc/	+*abc/	-	-	0#bc/	0#c/	-	0#c/	-	
Rabbit pox	Rabbits	-	-	-	+	-	-	-	-	+*INbc/; +*ch/	9, 163
Rauscher virus	Mice	-	-	-	+	-	-	-	-	-	56
Reovirus	Mice	-	-	-	-	-	-	-	-	+cdh/	149
Rhinotracheitis	Cats	-	-	-	-	-	-	-	-	+*INc/	124
Rift Valley fever	Lambs	-	-	-	-	-	-	-	-	-	37
	Mice	-	-	-	-	-	-	-	-	-	2/ 39, 2/ 2/ 102, 2/ 2/
	Monkeys	+*abc/	+*abc/	-	-	0#bc/	0#c/	-	0#c/	0#ICbc/	

Causative Agent of	Animals	Aerosol Exposure			Method of Inoculation				Other (IM, IT, Oral, IC, ID, IP, ICar, IO, IL)	Literature Cited
		Whole Body	Head Only	Nose & Mouth	IP	SC	IV	IM		
Variola	Monkeys	-	0*	-	-	-	-	-	+*IN	57, 109
Venezuelan equine encephalitis	Dogs	-	-	-	-	-	-	-	-	29, 152
	Guinea pigs	+*	+*sg/; 0*bg/	-	0*bg/; 0*cg/	-	-	+*	-	78, 79
	Horses	-	-	0*bg/	-	-	-	-	-	130, 131
	Mice	+*cs/; 0*bs/	-	-	+*bg/; 0*bc/	0*	-	-	0*ICbc/; +*ICbc/	99, 100, 101
	Monkeys	+*abc/	-	-	0*cg/	0*cg/	-	-	-	46, 145
	Pigeons	-	-	0*fg/	-	-	-	-	-	142
Vesicular stomatitis	Mice	-	-	-	+*dp/	-	-	-	+*IN	14, 22
	Swine	-	-	-	-	-	+*	-	-	148
Western equine encephalitis	Chickens	-	-	-	-	+*	-	+*	+*IC	56
	Snakes	-	-	-	-	0*cg/	-	-	-	56
Yaba	Monkeys	-	-	-	-	-	-	-	-	56
Yellow fever	Mice	+*cs/; 0*bs/	-	-	0*bg/	0*	-	-	0*ICbc/	56
	Monkeys	+*abc/	+*abc/	-	0*cg/	0*cg/	-	-	-	56

FP = foot pad, IC = intracerebral, ICar = intracardial, ID = intradermal, IL = intralingual, IM = intramuscular, IN = intranasal instillation, IO = intraocular, IP = intraperitoneal, IT = intratracheal, IV = intravenous, SC = subcutaneous

- + = Infection of control animals.
 0 = No infection of control animals.
 * = Infected and control cagemates in wire-bottomed or bar-bottomed cage that allowed urine and feces to drop through.
 # = Solid-bottomed cages or pens.
 a = But "0" if the monkey fur was forcibly air-washed by a manually manipulated air hose for 10 minutes.
 b = Control animals in separate but adjacent cages.
 c = Control animals in the same cage with the inoculated animals.
 d = Unknown whether the cage had a solid bottom or a bottom that permitted urine and feces to drop through.
 e = Method of inoculation not precisely stated.
 f = Exposed to aerosols, method not stated.
 g = Simultaneously infected intramuscularly and orally.
 h = Control animals placed in cage or pen with animals infected by contact transmission.
 i = In a tube, nose-to-nose in near contact with moribund mice.
 j = Challenge by dry arthropores.
 k = Challenge by wet and dry fragmented mycelia.
- l = Naturally infected animals caged with normal animals.
 m = Mother inoculated; litter test animal.
 n = Inoculated horse and control horse tied so that their heads could come in contact.
 o = Infection due to cannibalism.
 p = Mothers infected by inoculated sucklings.
 q = Only 1 infected among 59 control cagemates.
 r = But 1 of 6 controls was infected by viremic birds in an air-duct-connected cage.
 s = Animals were air-washed for 5 to 15 minutes after microbial aerosol exposure.
 t = 50 FC filter used.
 u = UV radiation used.
 v = Swine only.
 w = Wheeler, D.W.F., and Russell, W.; Unpublished results.
 x = Experimental controls from various sources.
 y = Except see literature Cited number 21.
 z = Experiments by Research Section, Research and Radiological Division, Industrial Health and Safety Directorate.

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TABLE 5. ASSESSMENT OF RISK OF HUMAN INFECTION IN THE
MICROBIOLOGICAL LABORATORY
A Comparative Review of Four Indicators of Risk

Causative Agent or Disease	Number of Reported Laboratory- Acquired Human Infections ^{2/} and Deaths ^{2/}	Infection of Control Animals ^{1/} by Animals Inoculated Other than by Oral or Respiratory Challenge ^{3/}	Reported Presence of the Inoculated Microorganism in Urine and/or Feces of the Inoculated Animals ^{4/}	Effective Vaccine, Toxoid, or Drug Therapy for Man
Abscetterov virus	1			?
Actinomycosis	3			
Adenovirus	8	+	+	yes
African swine fever	none		+	
Alaetian disease	none	+	+	
Amebiasis	20			yes
Anthrax	36 (3)	0	+	yes
Apeu virus	1	0		
Avian lymphomatosis	1	+d/	+	
Babaru virus	1			
Bittner agent	none		0	
Blastomycosis	8			?
Botulinum toxin	none	0g/	+	yes
Brucellosis	274 (2)	+	+	?
Bunyamvera	6			
Candidiasis	2			?
Caraparu virus	none	0		
Chikungunya virus	19			?
Cholera	9		+	yes
Coccidioidomycosis	108 (1)	0	+	?
Colorado tick fever	8			
Coxsackie virus	35		+	
Cryptococcosis	none		+	?
Cytomegalic inclusion disease	none		+	
Dengue	6		0L/	
Dermatophytoses	84			?
Diphtheria	40			yes
Distemper	none		0	
Eastern equine encephalitis	2	+	+	yes
ECHO virus	1		+	
Encephalomyocarditis	none		+	
Enterovirus			+	
Epidemic diarrhea of infant mice	none	+1/	+k/	
Erysipelothrix	32		+	
Foot-and-mouth disease	2	+	+	
Friend's virus	none	0	+	
Ganjam virus	2			
Germiston virus	3			
Glanders	14		+	yes
Gonorrhea	4			yes
<u>Hemophilus influenzae</u>	7			?
Hepatitis, infectious	126 (1)		+	
Herpes simplex virus	none	+	+	
Histoplasmosis	81	+1/	+	?
Hog cholera	none			
Hypr virus	4			
Ilheus virus	1			
Infectious bronchitis, avian	none	+1/		
Influenza virus	7	+	+	yes
Itaqui virus	none	0		
Japanese B encephalitis	2	0	+	yes
Junin virus	5 (1)	+	+	
Y virus	none		+	
Kemerovo virus	*			
Kunjin virus	2			
Kyasanur Forest disease	65		+	
Lactic dehydrogenase agent	none	+		
Leishmaniasis	4			
Lethal intestinal virus of infant mice	none			
Leptospirosis	45 (6)	0	+	
Looping ill	21	+		
Lymphocytic choriomeningitis	19 (2)	+	+	
Lymphogranuloma venereum	6			yes

Causative Agent or Disease	Number of Reported Laboratory-Acquired Human Infection ¹ and Deaths ²	Infection of Control Animals ³ by Animals Inoculated Other than by Oral or Respiratory Challenge ⁴	Reported Presence of the Inoculated Microorganism in Urine and/or Feces of the Inoculated Animals ⁵	Effective Vaccine, Toxoid, or Drug Therapy for Man
Machupo virus	4 (1)	+	+	
Malaria	13			yes
Mammary tumor	none		0	
Marek's disease	none	+1/0	+	
Marituba virus	1			
Mayaro virus	3			
Measles	1	+1/	+1/	yes
Melioidosis	none	+1/	+	yes
Meningopneumonitis of mice	none			
Meningococcus	5			yes
Moloney leukemogenic virus	none	0	+1/	
Monkey B virus	11 (9)	+	0	
Monkey pox	none	+		
Mouse hepatitis	none	+	+	
Mouse pox	none	+	+	
Mucambo virus	2			
Murutucu	none	0		
Mumps	3		+1/	yes
Mycoplasma (PPLO)	1	+	+1/	
Nairobi sheep disease	1			
Negishi virus	*			
Newcastle virus	32	+1/	+	
Nocardiosis	1			
Omsk hemorrhagic fever	3			
Oriboca virus	1	0		
Oropouche virus	2			
Ovine dermatitis	5			
Parainfluenza 5, DA	none		+	
<u>Pasteurella leptisepitica</u>	*			
Piry virus	5			
Plague	4 (1)	+	+	yes
Pneumococcus	4			yes
Pneumonia virus of mice	none	+1/		
Poliomyelitis	9 (2)	+1/	+	yes
Polyoma virus	none	+	+	
Povassan virus	1			
Pseudorabies (Aujeszky's disease)	1	+1/	0	
Psittacosis-ornithosis	70 (7)	+1/	+	yes
Q fever	184 (1)	+1/	+	yes
Rabbit pox	none	+1/		
Rabies	none		+1/	yes
Rat bite fever	14			
Rauscher virus	none			
Relapsing fever	16			
Reovirus	1	+1/	+	
Rhinotracheitis	none			
Rhinovirus	none		+	
Rickettsial pox	6			yes
Rift Valley fever	24 (1)	0	0	yes
Rinderpest	none	+	+	
Rio Bravo virus	5			
Rocky Mountain spotted fever	23 (1)	0		yes
Ross River virus	2			
Rous sarcoma	none	+1/		
Rubella	none	+	+	yes
Russian Far East encephalitis	*			
Russian spring-summer encephalitis	5 (2)	+1/	+	
St. Louis encephalitis	1	0	0	
Salmonellosis	54		+	yes
Sarcoma (SV-40) virus	none		+	
Scrapie	none	+		
Semliki Forest virus	1		0	
Sendai virus	none	+1/	+	

Causative Agent or Disease	Number of Reported Laboratory-Acquired Human Infections ^{2/} and Deaths ^{2/}	Infection of Control Animals ^{1/} by Animals Inoculated Other than by Oral or Respiratory Challenge ^{2/}	Reported Presence of the Inoculated Microorganism in Urine and/or Feces of the Inoculated Animals ^{3/}	Effective Vaccine, Toxoid, or Drug Therapy for Man
<i>Serratia marcescens</i>	4		+	
Shigellosis	54 (1)		+	yes
Smallpox	1		+	yes
Soviet hemorrhagic fever	113	+1/	+	
Spondweni virus	2			
Sporotrichosis	7			yes
Staphylococcal enterotoxin	none		+	
Staphylococcus	19 (1)			yes
Streptococcus	67 (3)			yes
Swine pox	none		0	
Teschen disease	none		+	
Tetanus	6			yes
Theiler's virus	none	+a/	+	
Toxoplasmosis	21 (1)			
Trachoma	5			
<i>Treponema pallidum</i>	10			yes
Trypanosomiasis	5			
Tsutsugamushi (scrub typhus)	12		0	yes
Tuberculosis	174 (5)	+	+	yes
Tularemia	129 (1)	+f/	+	yes
Typhoid fever	292 (21)		+	yes
Typhus (endemic)	82 (4)		+	yes
Typhus (epidemic)			0	yes
Vaccinia	9	+	+	yes
Venezuelan equine encephalitis	118 (1)	+	+	yes
Vesicular stomatitis	54	+		
<i>Vibrio fetus</i>	1			
Viral pneumonia (atypical)	*			
Wesselsbron virus	4			
Western equine encephalitis	6 (2)	+d/	+d/	?
West Nile virus	13			
Yaba virus	none			
Yellow fever	38 (6)	0	0	yes
Zika virus	1			

* = Reference does not specify details or how many cases.

0 = Negative in all animals tested.

+ = Positive in some species by at least one method of inoculation, but not necessarily in all species tested.

a = Uninoculated animals caged with or near inoculated animals. See Table 4 for more details.

b = Respiratory challenge - aerosol exposure, intratracheal inoculation, intranasal instillation.

c = See Table 3.

d = Only avian species were +.

e = Cat only; not in guinea pig, hamster, or monkey.

f = Mice only, rare and irregular; other species 0. See Table 4.

g = Method of inoculation not precisely stated.

h = Man only; not in hamsters or mice.

i = Man only; no other species tested.

j = Milk of parenterally inoculated mothers had transmitted the virus to these otherwise uninoculated mice.

k = After oral inoculation.

l = Only naturally infected animals caged with normals.

m = Swine only; not in rabbits, white rats, mice, or guinea pigs.

n = Infection due to cannibalism.

o = See Table 1.

p = Number in parentheses refers to deaths.

q = Only one mouse infected among 59 control cagemates.

r = Control animals placed in cage or pen with animals infected by contact transmission.

s = Murine mother inoculated; litter test animal infected.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D																		
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13. ABSTRACT In estimating the risk of human infection during research in the microbiological laboratory and in deciding upon appropriate safeguards, it is useful to know the nature of the work in terms of (i) potential accidental microbial aerosol formation and accidental injection, ingestion, cut, and bite; (ii) the number of recorded laboratory infections and their outcome; (iii) the medical prophylactic procedures available; (iv) whether the microorganism is excreted in urine and feces; and (v) whether inoculated animals infect normal cagemate control animals. Detailed tabular summaries with 700 references and working assumptions pertinent to these matters are presented for 162 causative agents or diseases.																		
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