Biological Agent Health Action Grid

The following grid summarizes medical intervention and transmission features of biological agents recognized as infectious to healthy human adults. The sources for foonote information include: CDC/NIH's Biosafety in Microbiological and Biomedical Laboratories, 5th edition; CDC/HHS's Advisory Committee on Immunization Practices; and the APHIS/CDC's National Select Agent Registry/Select Agents Exclusion. This document is intended to serve as a general information guide. A full risk assessment needs to be prepared for the use of any infectious agent in a lab or animal research setting, and appropriate research compliance committee approvals obtained before work is initiated.

	Biosafety/Public Health Features			
Infectious Agent (disease)	**Fetal Risk (Y/N)**	**Specific, Well-Documented Natural Reservoir**	**Air-Borne Risk (Y/N)**	**Vaccine Availability? (Y/N)**
BACTERIAL AGENTS				
Bacillus anthracis, Sterne strain (anthrax)[1]	N	Soil, dried or pressed hides	N	Y[2]
Bordetella pertussis (whooping cough or pertussis)	N	Humans	Y[3]	Y[4]
Brucella abortus Strains 19 and RB51 (brucellosis)[5]	N	Mammals, especially cattle	N	N[6]
Campylobacter spp. (campylobacteriosis, traveler's diarrhea)	N	Domesticated animals, rodents, birds	N	N
Chlamydia trachomatis, Chlamydia pneumoniae (lymphogranuloma venereum, trachoma, pneumonia)	Y[7]	Humans	Y[8]	N
Chlamydia psittaci (psittacosis or parrott fever)	Y[7]	Psittacine birds (parrots, parakeets, etc.), poultry	Y[8]	N
Clostridium tetani (tetanus or lockjaw)	N	Intestine of animals and humans	N	Y[4]
Corynebacterium diphtheriae (diphtheria)	N	Soil contaminated with animal/human feces	N	Y[4]

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Francisella tularensis, subspecies novicida U112 and subspecies holartica LVS (tularemia or rabbit fever)[9]	N	Wild animals, esp. rabbits, hard ticks, deerfly, mosquitoes, birds	N	N[10]
Helicobacter spp. (chronic gastritis, peptic ulcer disease)	N	Humans, Old World macaques, dogs, cats and other mammals, birds, houseflies, raw vegetables	N	N
Legionella pneumophila (Pontiac fever or Legionnaire's disease)	N	Fresh water sources, man-made warm water systems, soil	N[11]	N
Leptospira spp. (leptospirosis)	N	Farm and pet animals, rodents	N	N
Listeria monocytogenes (listeriosis)	Y[12]	Domesticated and wild mammals, fowl and humans	N	N
Mycobacterium leprae (leprosy or Hansen's disease)	N	Humans	N	N
Mycobacterium tuberculosis complex - M. tuberculosis, M. bovis, M. africanum, M. microti, M. caprae and M. pinnipedii (tuberculosis)	N	Humans and other mammals	Y[13]	Y[14]
Neisseria gonorrhea (gonorrhea)	N[7]	Humans	N[15]	N
Neisseria meningitidis (meningococcal disease or bacterial meningitis)	N	Humans	N	Y[16]
Salmonella typhi (typhoid fever)	N	Humans	N[17]	Y[18]
Salmonella other than S. typhi (salmonellosis)	N	Humans, domesticated and wild animals	N[17]	N
Shiga toxin-producing E. coli, i.e. O157:H7	N	Farm animals, infected humans	N[17]	N

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Shigella (shigellosis or dysentery)	N	Humans, NHPs	N	N[19]
Streptococcus pneumoniae (pneumonia)	N	Humans	N	Y[20]
Treponema pallidum (syphilis)	Y[7]	Humans	N	Y[21]
Vibrio cholerae/Vibrio parahaemolyticus (cholera/ gastroenteritis)	N	Humans, animals around aquatic environments/ bivalve shellfish	N	Y[22]
Yersinia pestis, Pgm- and Lcr- strains (plague)[23]	N	Wild rodents	N	Y[24]
FUNGAL AGENTS				
Blastomyces dermatitidis (blastomycosis)[25]	N	Moist soil and decomposing vegetation and wood	Y[26]	N
Cryptococcus neoformans (cryptococcosis)	N	Humans and various domesticated and wild animals	N	N
Dermatophytes - Epidermophyton, Microsporum, Trichophyton (dermatophytosis, tinea, ringworm, jock itch, athletes foot, onychomycosis)[27]	N	Humans and other mammals, soil	N	N
Histoplasma capsulatum (histoplasmosis)	N	Nitrogen rich soils	Y[28]	N
Sporothrix schenckii (sporotrichosis)	N	Soil, surface water, decaying vegetation, wood, moss, hay, grain, and marine animals	N[29]	N

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
PARASITIC AGENTS				
Blood and Tissue Protozoal Parasites: Babesia (babesiosis or piroplasmosis),[30] Leishmania (leishmaniasis), Plasmodium (malaria), Toxoplasma (toxoplasmosis), Trypanosoma cruzi (Chaga's disease), Trypanosoma brucei (African trypanosomiasis), Acanthamoeba (amoebic keratitis and encephalitis, Balamuthia mandrillaris (amoebiasis), Naegleria fowleri (naegleriasis), and Microsporidia	Y[31]	Acanthamoeba-soil, fresh water Leishmania-humans, other warm-blooded mammals Microsporidia-all animal species Naegleria-fresh water, soil, sewage, sludge, dust, nasal passages/throats of healthy humans Plasmodium-humans, other animals Trypanosoma-primarily humans, wild game, cattle, lions, hyenas T. gondii - cats	N	N[32]
Intestinal Protozoal Parasites: Cryptosporidium (cryptosporidosis), Isospora (isosporiasis), Entamoeba histolytica (amebiasis), Giardia (giardiasis), Septata intestinalis and Enterocytozoon bieneusi (diarrhea)[33]	N	Cryptosporidium-humans, cattle, other domesticated animals Entamoeba-humans Enterocytozoon-pigs Giardia-humans, wild and domesticated animals	N	N[34]

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Trematode Parasites: Schistosoma spp. (schistosomiasis) and Fasciola (fascioliasis or sheep liver fluke disease)	N	Schistosoma-humans, cats, dogs, cattle, pigs, horses, water buffalo, rodents Fasciola-fresh water snails, aquatic plants, mammals including humans	N	N[35]
Cestode Parasites: Echinococcus spp. (echinococcosis), Hymenolepis nana (hymenolepsis), and Taenia solium (taeniosis and cysticercosis)	N	Echinococcus-foxes and other canines Hymenolepis-humans Taenia-pigs, humans	N	N[36]
Nematode Parasites: Ancylostoma (hookworm), Ascaris (ascariasis), Baylisascaris (baylisascariasis), Strongyloides (strongyloidiasis), Enterobius (enterobiasis), Wuchereria (lymphatic filariasis or elephantiasis) and Brugia (lymphatic filariasis)[37]	N	Ancylostoma-humans, dogs Ascaris-humans, swine, soil Baylisascaris-various animal species Brugia-humans, cats, civets, NHPs, mosquitoes Enterobius-humans, chimps Strongyloides-various mammals	N[38]	N
RICKETTSIAL AGENTS				
Coxiella burnetti, Phase II, Nine Mile Strain (Q fever)[39]	N	Domesticated and wild mammals, particularly sheep, ticks, birds	N	N
VIRAL AGENTS				
Cowpox virus (cowpox)[40]	N	Wild rodents	Y[41]	Y[42]
Epstein-Barr virus (infectious mononucleosis)[43]	N	Humans	N	N

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Hantaviruses (hemorrhagic fever with renal syndrome (HFRS) and hantavirus pulmonary syndrome (HPS)	N	Small rodents (e.g. mice, rats, voles)	Y[44]	N
Haemophilus influenzae type B (epiglottitis and lower respiratory tract infections in children, Hib meningitis)	N	Humans	N	Y[45]
Hepatitis A virus (hepatitis A)	N	Humans, NHP	N[46]	Y[47]
Hepatitis B virus (hepatitis B)[48]	Y[7]	Unknown, but humans and NHPs are susceptible	N	Y[49]
Hepatitis viruses C and D (hepatitis C, hepatitis D)[48]	N	Humans, NHP	N	N[50]
Hepatitis E virus (hepatitis E)	Y[51]	Humans, NHPs and other animals	N	N
Herpes simplex virus 1 (cold sores, fever blisters)[43]	Y[7]	Humans	N	N
Herpes simplex virus 2 (genital herpes)[43]	Y[7]	Humans	N	N
Human cytomegalovirus[43]	Y[52]	Humans	N	N
Human herpesviruses 6A (roseola), 6B, 7 and 8 (Kaposi's sarcoma)[43]	N[53]	Humans	N	N
Human immunodeficiency virus (acquired immune deficiency syndrome or AIDS)[54]	Y[7]	Humans	N	N
Human papillomavirus (genital warts, cervical cancer)	Y[55]	Humans	N	Y[56]
Influenza virus (influenza or "flu")	N	Swine, horses, mink, seals and domestic and wild avian species	Y[57]	Y[58]

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Junin virus, vaccine strain Candid #1 (Argentine hemorrhagic fever)[59]	N	Calomys musculinus, Calomys laucha (vesper mouse)	Y[60]	Y[61]
Lymphocytic choriomeningitis virus (lymphocytic meningitis)	Y[62]	House mouse (Mus musculus)	N	N
Measles/Mumps/Rubella viruses (measles/mumps/rubella)	Y[63]	Humans	N	Y[64]
Monkeypox virus (smallpox-like disease)[40,65]	N	Monkeys, rodents, African squirrels	Y[41,66]	Y[42]
Polio virus (poliomyelitis)	N	Humans	N	Y[67]
Rabies virus (rabies)	N	Bats, terrestrial carnivores	N[68]	Y[69]
Simian immunodeficiency virus (simian AIDS)[7]	N	Humans, NHPs	N	N
Severe Acure Respiratory Syndrome Coronavirus (SARS pneumonia, respiratory distress syndrome)[70]	N	Masked palm civets, bats	Y[71]	N
Vaccinia (smallpox)[72]	N	Humans	N[41]	Y[42,72]
Varicella-Zoster virus (chickenpox, shingles)[43]	N	Humans	Y[73]	Y[74]
Variola virus (smallpox)[40,75]	N	Humans	Y[41]	Y[42]
ARBOVIRUSES (arthropod transmitted viruses)				
Chikungunya (chikungunya fever)	N	Humans, monkeys, rodents, bats, birds	N[60]	N
Dengue Virus Types 1, 2, 3 and 4 (dengue fever)	N	Humans, NHPs	N[76]	N
Japanese Encephalitis Virus, vaccine strain SA 14-14-12 (encephalitis)[77]	N[78]	Domesticated pigs, wild birds	N	Y[79]

Infectious Agent (disease)	Fetal Risk (Y/N)	Specific, Well-Documented Natural Reservoir	Air-Borne Risk (Y/N)	Vaccine Availability? (Y/N)
Rift Valley Fever Virus, vaccine strain MP-12 (Rift Valley fever)[80]	N	Unknown	N	Y[81]
Ross River Virus (Ross River fever)	N	Unknown	N[59]	N
Sindbis (Sindbis fever)	N	Birds	N	N
Venezuelan Equine Encephalitis Virus, vaccine strains TC83 and V3526 (Venezuelan equine encephalitis or encephalomyelitis)[82]	N	Enzootic-rodents and mosquitoes Epizootic-horses, humans, mosquitoes	N[59]	Y[83]
West Nile Virus (West Nile fever, West Nile meningitis or encephalitis)	N	Birds	N[84]	N
Western Equine Encephalitis Virus (Western equine encephalitis)	N	Wild birds, mosquitoes	Y[85]	Y[86]
Yellow fever virus (yellow fever)	Y[87]	Humans	N	Y[88]

FOOTNOTES

The sources for foonote information include: CDC/NIH's Biosafety in Microbiological and Biomedical Laboratories, 5th edition; CDC/HHS's Advisory Committee on Immunization Practices; and the APHIS/CDC's National Select Agent Registry/Select Agents Exclusion.

[1]While *B. anthracis* is a Select Agent, *B. anthracis* Sterne is an avirulent, attenuated strain. Both HHS and USDA have determined that this strain is not subject to the requirements of 42 CFR Part 73 and 9 CFR Part 121 if used in basic or applied research, as positive controls, for diagnostic assay development, or for the development of vaccines and therapeutics. In addition, this strain has been used to vaccinate both humans and animals and does not pose a severe threat to public health and safety.

[2]A licensed vaccine for anthrax is available. Worker vaccination is recommended for activities that present an increased risk for repeated exposures to *B. anthracis* spores including: 1) work involving production quantities with a high potential for aerosol production; 2) handling environmental specimens, especially powders associated with anthrax investigations; 3) performing confirmatory testing for *B. anthracis,* with purified cultures; 4) making repeated entries into known *B. anthracis*-spore-contaminated areas after a terrorist attack; and 5) work in other settings in which repeated exposure to aerosolized *B. anthracis* spores might occur. Vaccination is not recommended for workers involved in routine processing of clinical specimens or environmental swabs in general diagnostic laboratories.

[3]The natural mode of transmission for *B. pertussis* is via the respiratory route. Since aerosol generation during the manipulation of cultures and contaminated clinical specimens generates the greatest potential hazard, the BMBL recommends that primary containment devices and equipment, including biological safety cabinets, safety centrifuge cups or safety centrifuges, should be used for activities likely to generate potentially infectious aerosols.

[4]The pertussis vaccine is available for adults and is given in combination with the vaccines against diphtheria and tetanus, also known as Tdap.

[5]*Brucella abortus* Strain 19 is a vaccine strain and was used to immunize more than 8 million people in the USSR. While there have been reports of human brucellosis caused by this strain as a result of accidental aerosolization or needle sticks, this strain does not pose a severe threat to human or animal health. Strain RB51 is less virulent than *Brucella abortus* Stain 19 and also does not pose a significant threat to human or animal health.

[6]Human Brucella vaccines have been developed and tested in other countries with limited success, but none are available in the United States. Note that occasional hypersensitivity reactions to Brucella antigens have occurred in workers exposed to experimentally and naturally infected animals or their tissues.

[7]These sexually transmitted diseases (STDs) can be passed from a pregnant woman to the baby before, during, or after the baby's birth. Some STDs (like syphilis) cross the placenta and infect the baby while it is in the uterus (womb). Other STDs (like chlamydia, gonorrhea, hepatitis B, and genital herpes) can be transmitted from the mother to the baby during delivery as the baby passes through the birth canal. HIV can cross the placenta during pregnancy, infect the baby during the birth process, and unlike most other STDs, can infect the baby through breastfeeding.

[8]The BMBL recommends BSL-3 practices, containment equipment, and facilities for activities involving any of these *Chlamydia* species with high potential for droplet or aerosol production and for activities involving large quantities or concentrations of infectious materials.

[9]Although *F. tularemia* is a select agent, these strains are not subject to the requirements of 42 CFR Part 73 and 9 CFR Part 121 if used in basic or applied research, as positive controls, for diagnostic assay development, or for the development of vaccines and therapeutics. The Utah 112 strain is not known to infect man and thus is not a public health concern.

[10]The LVS (live vaccine strain) has been used to vaccinate millions of people including thousands of U.S. military personnel and laboratory workers against tularemia infection without major problems.

[11]Since aquatic sources are the major reservoir, the mode of transmission is aerosolization, aspiration or direct inoculation into the airway. The BMBL recommends BSL-2 with BSL-3 practices for activities likely to produce extensive aerosols and when large quantities of *Legionella* are manipulated.

[12]Pregnant women and their fetuses, newborns, and persons with impaired immune function are at greatest risk of developing severe infections including sepsis, meningitis, and fetal demise. In pregnant women, *Listeria monocytogenes* infections occur most often in the third trimester and may precipitate labor. Transplacental transmission of *L. monocytogenes* poses a grave risk to the fetus.

[13]Infectious aerosols produced by coughing spread tuberculosis. *Mycobacterium bovis* is primarily found in animals but can also produce tuberculosis in humans. The BMBL requires BSL-3 practices, containment equipment, and facilities for laboratory activities involving the propagation and manipulation of cultures of any of the subspecies of the *M. tuberculosis* complex (and for animal studies using experimentally or naturally infected NHPs. BSL-3 practices should include the use of respiratory protection and the implementation of specific procedures and use of specialized equipment to prevent and contain aerosols. Animal studies using guinea pigs or mice can be conducted at ABSL-2.

[14]The attenuated live BCG is available and used in other countries but is not used in the United States for immunization against tuberculosis. Annual or semi-annual skin testing with purified protein derivative (PPD) of previously skin-test-negative personnel can be used as a surveillance procedure.

[15]The BMBL recommends additional primary containment and personnel precautions such as those described for BSL-3 when there is high risk of aerosol or droplet production from *N. gonorrhea*, and for activities involving production quantities or high concentrations of infectious materials.

[16]Laboratorians who are exposed routinely to potential aerosols of *N. meningitidis* should consider vaccination. The quadrivalent meningococcal polysaccharide vaccine, which includes serogroups A, C, Y, and W-135, will decrease but not eliminate the risk of infection, because it is less than 100% effective and does not provide protection against serogroup B, which caused one-half of the laboratory-acquired cases in the United States in 2000.

[17]The BMBL recommends conducting procedures with aerosol or high splash potential in primary containment devices such as a BSCs or safety centrifuge cups when working with species of *Salmonella* and Shiga-producing *E. coli*.

[18]Vaccines for *S. typhi* are available and should be considered for personnel regularly working with potentially infectious materials. The reader is advised to consult the current recommendations of the ACIP for recommendations for vaccination against *S. typhi*.

[19]Vaccines against *Shigella* are currently unavailable for use in humans.

[20]A polyvalent vaccine containing capsular polysaccharides is available for those at high risk of fatal infection from *S. pneumoniae* (vaccine should be given only once to adults to avoid systemic reactions to a second dose).

[21]Since there are no vaccines currently available for use in humans, periodic serological monitoring should be considered in personnel regularly working with materials infected with *T. pallidium*.

[22]Consult the current recommendations of the ACIP published in the MMWR for vaccination recommendations for *V. cholera*. There are currently no human vaccines against *V. parahaemolyticus*.

[23]Although *Y. pestis* is a Select Agent, these strains pose no significant threat to public health. Pgm- mutant strains, such as EV 76, are avirulent, while strains lacking the Lcr plasmid (Lcr-), such as Tjiwidej S and CDC A1122, are irreversibly attenuated due to the loss of a virulence plasmid.

[24]The Pgm- mutant strains have been used for years as live human vaccines with no significant plague-associated problems. Tjiwidej S has been extensively used as a live vaccine in humans in Java.

[25]Yeast forms of *B. dermatitidis* may be present in the tissues of infected animals and in clinical specimens. Parenteral (subcutaneous) inoculation of these materials may cause local skin infection and granulomas.

[26]Mold form cultures of *B. dermatitidis* containing infectious conidia, and processing of soil or other environmental samples, may pose a hazard of aerosol exposure.

[27]Systemic dermatophytosis is a rare condition. Superficial chronic infections occur frequently among immunocompromised individuals, as well as elderly and diabetic persons. Susceptible individuals should use extra caution.

[28]When propagating sporulating cultures of *H. capsulatum* in the mold form, as well as processing soil or other environmental materials known or likely to contain infectious conidia, BSL3 practices and containment are recommended.

[29]Although localized skin and eye infections have occurred in an occupational setting, no pulmonary infections have been reported as a result from laboratory exposure to *S. schenckii*. It should be noted that serious disseminated infections have been reported in immunocompromised persons.

[30]Persons who are asplenic, immunocompromised, or elderly have increased risk for severe illness if infected with *B. microti* or other *Babesia spp*. Immunocompromised persons should avoid working with live organisms or receive individualized counseling (specific to host and parasite factors) from their personal healthcare provider and their employer about the potential risks associated with working with live organisms.

[31]Because of the potential for grave consequences of toxoplasmosis in the developing fetus, women who are or might become pregnant and who are at risk for infection with *T. gondii* should receive counseling from their personal physician and employer regarding appropriate means of mitigating the risk (including alternate work assignments, additional PPE, etc.).

[32]Although no vaccines are available, highly effective medical treatment exists for infections caused by most of these blood and tissue protozoal parasites.

[33]These intestinal protozoal parasites do not require more than one host to complete their life cycle because they infect, develop, and result in shedding of infectious stages all in a single host. Immunocompromised persons should avoid working with live organisms.

[34]Highly effective medical treatment exists for most protozoal infections; treatment with nitazoxanide for *Cryptosporidium* is now available, but efficacy has not been proven.

[35]No vaccines are available, but highly effective medical treatment for most trematode infections exist.

[36]Although no vaccines are currently available, highly effective medical treatment for most cestode infections exists. Immunocompromised persons working with these cestodes must take special care as the asexual multiplication of the larval stages of these parasites makes them especially dangerous to such persons.

[37]Working with infective eggs of other ascarids, such as *Toxocara* and *Baylisascaris*, poses significant risk because of the potential for visceral migration of larvae, including invasion of the eyes and central nervous system.

[38]No vaccines are available. Allergic reactions to various antigenic components of human and animal ascarids (e.g., aerosolized antigens) may pose risk to sensitized persons. Development of hypersensitivity is common in laboratory personnel with frequent exposure to aerosolized antigens of ascarids. *Strongyloides stercoralis* is of particular concern to immunosuppressed persons because potentially life-threatening systemic hyperinfection can occur.

[39]*C. burnetii* undergoes a virulent (Phase I) to avirulent (Phase II) transition upon serial laboratory passage in eggs or tissue culture. Research has shown that plaque-purified (cloned) isolates of the Nine Mile Strain phase II organisms do not undergo phase reversion and are avirulent since inoculation of suspectible animals with phase II cells do not result in infection nor can viable phase II or phase I organisms be recovered from the spleens of these animals. Therefore, HHS and USDA have determined that this strain does not pose a significant threat to human or animal health.

[40]Laboratory-acquired poxvirus infections of most concern are from the orthopoxviruses that infect humans: variola virus, monkeypox virus, cowpox virus, and vaccinia virus. Since smallpox has been eradicated from the world since 1980, these diseases now occur as zoonoses in humans.

[41]Poxviruses may enter the body through mucous membranes exposure or droplet or fine-particle aerosol inhalation. Sources of laboratory-acquired infection include exposure to aerosols, environmental samples, naturally or experimentally infected animals, infectious cultures, or clinical samples, including vesiculopustular rash lesion fluid or crusted scabs, various tissue specimens, excretions and respiratory secretions. Primary containment devices (e.g., BSC) should be utilized to prevent exposure of workers to infectious aerosols. Additional containment and procedures, such as those described for BSL-3, should be considered when producing, purifying, and concentrating human herpesviruses, based on risk assessment.

[42]Routine vaccination is no longer carried out as smallpox has now been eradicated. However, all persons working in or entering laboratory or animal care areas where activities with vaccinia, monkey pox, or cowpox viruses are being conducted should have evidence of satisfactory smallpox vaccination. Vaccination is advised every three years for work with monkeypox virus and every 10 years for cowpox and vaccinia viruses. Vaccination is not required for individuals working only in laboratories where no other orthopoxviruses or recombinants are handled.

[43]All human herpesviruses (i.e. herpes simplex virus 1, herpes simplex virus 2, Varicella-Zoster virus, Epstein-Barr virus, human cytomegalovirus, and human herpesviruses 6, 7 and 8) pose an increased risk to persons who are immunocompromised. The BMBL recommends primary containment devices (e.g., BSC) to prevent exposure of workers to infectious aerosols.

[44]Laboratory transmission of hantaviruses from rodents to humans via the aerosol route is well documented. The BMBL recommends the use of a certified BSC for all handling of human body fluids or whenever procedures with potential exists for splatter or aerosol.

[45]Vaccination with Hib conjugate vaccine is effective in preventing Hib infection. Several vaccines are now available for routine use against Hib, but vaccines are not yet available against the unencapsulated strains termed nontypable (NTHi) because they lack capsular serotypes.

[46]There is no evidence that aerosol exposure results in *Hepatitis A* infection.

[47]A licensed inactivated vaccine against *Hepatitis A* is available.

[48]Individuals who are infected with the *Hepatitis B virus* (HBV) are at risk of infection with *Hepatitis D virus* (HDV), a defective RNA virus that requires the presence of HBV virus for replication. Infection with HDV usually exacerbates the symptoms caused by HBV infection.

[49]Licensed recombinant vaccines against HBV are available and are highly recommended for and offered to laboratory personnel. The HBV vaccine will prevent infection with HBV as well as HDV in HBV seronegative individuals.

[50]Unlike hepatitis A and B, there is currently no vaccine to prevent hepatitis C infection. Vaccination against *Hepatitis B virus*will also prevent *Hepatitis D virus* infection.

[51]*Hepatitis E virus* appears to be less of a risk to personnel than *Hepatitis A virus*, except during pregnancy, when infection can result in severe or fatal disease.

[52]*Human cytomegalovirus* (HCMV) may pose a special risk during pregnancy because of potential infection of the fetus. HCMV is one of the most common congenital diseases and causes up to 10% of all cases of mononucleosis in young adults. The most severe form of the disease is seen in infants infected *in utero*. Children surviving infection may evidence mental retardation, microencephaly, motor disabilities and chronic liver disease.

[53]*Human Herpes Virus-6* (HHV-6) may reactivate in immunocompetent individuals during pregnancy or during critical illness. At least one report has provided evidence that in African children, HHV-8 infection may be transmitted from mother to child.

[54]It is recommended that all institutions establish written policies regarding the management of laboratory exposure to *Human Immunodeficiency Virus* and *Simian Immunodeficiency Virus*, including treatment and prophylaxis protocols.

[55]Genital *Human Papilloma Virus* (HPV) infection is primarily transmitted by genital contact, usually through sexual intercourse. Genital HPV infection also can be transmitted by nonsexual routes, but this is uncommon. Nonsexual routes of genital HPV transmission include transmission from a mother to a newborn baby.

[56]A licensed quadrivalent vaccine for HPV is available.

[57]All personnel should be enrolled in an appropriately constituted respiratory protection program. The use of negative pressure, HEPA-filtered respirators or positive air-purifying respirators (PAPRs) are recommended for work involving the non-contemporary, wild-type human influenza (H2N2) strains.

[58]Vaccines for *Influenza* are available, and the Advisory Committee on Immunization Practices (ACIP) should be consulted for current recommendations.

[59]Although Junin is classified as a Select Agent by the HHS, vaccine strain Candid #1 is excluded.

[60]The BMBL recommends HEPA-filtered lab exhaust for laboratories conducting work with Chikungunya, Junin, Rift Valley Fever and Venezuelan Equine Encephalitis viruses.

[61]An inactivated vaccine against the wild-type *Junin virus* is available.

[62]Pregnant women infected with *Lymphocytic Choriomeningitis Virus* (LCMV) have transmitted the virus to their fetuses with death or serious central nervous system malformation as a consequence. Vaccines are not available for use in humans.

[63]Women in their first trimester who contract rubella have an increased risk of passing the infection to the developing fetus. Women who may become or are pregnant, if seronegative, should be restricted from working with *Rubella*. Immune globulin given after exposure in pregnancy may modify or suppress symptoms but may not prevent infection.

[64]The MMR vaccine is a mixture of all three live attenuated viruses. Vaccination for women is suggested one month before conception if not previously vaccinated.

[65]Monkeypox virus is endemic in rodents in parts of Africa. Importation of African rodents into North America in 2003 resulted in an outbreak of monkeypox in humans.

[66]People can get monkeypox from an animal with monkeypox if they are bitten or if they touch the animal's blood, body fluids, or its rash. ABSL-3 practices, containment equipment, and facilities are recommended for monkeypox work in experimentally or naturally infected animals. BSL-2 facilities with BSL-3 practices are advised if vaccinated personnel perform other work with monkeypox virus. These practices include the use of Class I or II BSCs and barriers, such as safety cups or sealed rotors, for all centrifugations.

[67]Laboratory personnel working with materials infected with poliovirus must have documented polio vaccination. Both inactivated poliovirus vaccine (IPV) and oral poliovirus vaccine (OPV) are highly effective in preventing disease, but neither vaccine provides complete protection against infection. Persons who have had a primary series of OPV or IPV and who are at an increased risk can receive another dose of IPV, but available data do not indicate the need for more than a single lifetime IPV booster dose for adults.

[68]For routine diagnostic activities involving *Rabies* being conducted outside the BSC, the BMBL recommends the use of appropriate methods and personal protection equipment, including dedicated laboratory clothing, heavy protective gloves to avoid cuts or sticks from cutting instruments or bone fragments, and a face shield or PAPR to protect the skin and mucous membranes of the eyes, nose, and mouth from exposure to tissue fragments or infectious droplets.

[69]Pre-exposure rabies vaccination is recommended for all individuals prior to working with lyssaviruses or infected animals, or engaging in diagnostic, production, or research activities. Rabies vaccination also is recommended for all individuals entering or working in the same room where lyssaviruses or infected animals are used. Prompt administration of post-exposure booster vaccinations is recommended following recognized exposures in previously vaccinated individuals per current guidelines.

[70]Institutions performing work with the *SARS-CoV* or handling specimens likely to contain the agent should develop and implement a specific occupational medical plan with respect to this agent and equire storage of a baseline serum sample from individuals who work with the virus or virus-containing specimens. Personnel working with the virus or samples containing or potentially containing the virus should be trained regarding the symptoms of *SARS-CoV* infection and counseled to report any fever or respiratory symptoms to their supervisor immediately. Further information and guidance regarding the development of a personnel exposure response plan is available from the CDC.

[71]In the rare event that a procedure or process involving untreated specimens cannot be conducted in a BSC, the BMBL recommends the use of gloves, gown, eye protection, and respiratory protection (acceptable methods of respiratory protection include: a properly fit-tested, National Institute for Occupational Safety and Health [NIOSH]-approved filter respirator [N-95 or higher level] or a PAPR equipped with HEPA filters). All personnel who use respiratory protective devices should be enrolled in an appropriately constituted respiratory protection program. In the event of any break in laboratory procedure or accidents (e.g., accidental spillage of material suspected of containing SARS-CoV), procedures for emergency exposure management and/or environmental decontamination should be immediately implemented and the supervisor should be notified. The worker and the supervisor, in consultation with occupational health or infection control personnel, should evaluate the break in procedure to determine if an exposure occurred.

[72]Vaccinia virus is the live viral component of the current smallpox vaccine and may occur as a rare zoonosis. It is the leading agent of laboratory-acquired poxvirus infections. Laboratory-acquired infections with standard, mutant, or bioengineered forms of vaccinia virus have occurred, even in previously vaccinated laboratorians. The NIH Guidelines have assessed the risk of manipulating attenuated vaccinia strains (modified virus Ankara [MVA], NYVAC, TROVAC, and ALVAC) in areas where no other human orthopoxviruses are being used and have recommended BSL-1. However, higher levels of containment are recommended if these strains are used in work areas where other orthopoxviruses are manipulated. Vaccination is not required for individuals working only in laboratories where no other orthopoxviruses or recombinants are handled.

[73]Varicela is spread by coughing and sneezing (highly contagious), by direct contact, and by aerosolization of virus from skin lesions.

[74]A live, attenuated vaccine for *Varicella Zoster* is licensed and available in the United States. In the event of a laboratory exposure to a non-immune individual, *Varicella* vaccine is likely to prevent or at least modify disease.

[75]Except for laboratory stockpiles, the variola virus has been eliminated. Worldwide, all live variola virus work is to be done only within WHO approved BSL-4/ABSL-4 facilities; one is at the CDC in Atlanta and the other is at the State Research Center of Virology and Biotechnology (VECTOR) in Koltsovo, Russia.

[76]The BMBL recommends properly maintained BSCs, preferable Class II, or other appropriate personal protective equipment or physical containment devices are used whenever procedures involving *Dengue* with a potential for creating infectious aerosols or splashes are conducted.

[77]Although *Japanese encephalitis virus* (JEV) is classified as a Select Agent by the USDA, strain SA 14-14-2 is excluded. This strain is the vaccine strain of choice in the People's Republic of China to protect against JEV. It is nonpathogenic in weanling mice and rhesus monkeys.

[78]Direct person-to-person spread of JEV does not occur except rarely through intrauterine transmission.

[79]Two JEV vaccines are licensed in the United States.

[80]Although Rift Valley Fever Virus (RVFV) is classified as a Select Agent by HHS and USDA, the live-attenuated MP-12 vaccine strain is specifically exempted from the Select Agent rules.

[81]Two apparently effective vaccines against RVFV have been developed by the Department of Defense (DoD) and have been used in volunteers, laboratory staff, and field workers under investigational protocols, but neither vaccine is available at this time.

[82]Although Venezuelan Equine Encephalitis Virus (VEEV) is classified as a Select Agent by HHS and USDA, the attenuated vaccine strains TC83 and V3526 are excluded. Strain V3526 is an attenuated strain of VEE which was constructed by site-directed mutagenesis rendering it a stable, nonpathogenic virus. This strain does not pose a significant threat to human or animal health and is considerably less virulent than the excluded vaccine strain TC83.

[83]The investigational formalin inactivated TC-83 vaccine is available and recommended for lab workers, but it is not available for the general population. This vaccine is quite effective in preventing infection by the epizootic strains of the VEEV. Investigational vaccines are administered under a cooperative agreement between the U.S. Army and the individual's requesting organization. Non-licensed vaccines for VEEV are available in limited quantities and administered on-site at the Special Immunization Program of USAMRIID.

[84]The Subcommittee on Arbovirus Laboratory Safety (SALS) reported 15 human West Nile Virus (WNV) infections from laboratory accidents in 1980. One of these infections was attributed to aerosol exposure. The BMBL recommends BSL-3 and ABSL-3 practices, containment equipment, and facilities for all manipulations of WNV cultures and for experimental animal and vector studies, respectively.

[85]Due to the high risk of aerosol infection, additional personal protective equipment, including respiratory protection, should be considered for non-immune personnel working with Western equine encephalitis virus (WEEV).

[86]Investigational WEEV vaccine protocols have been developed to immunize at-risk laboratory or field personnel, however, the vaccine(s) is available only on a limited basis and may be contraindicated for some personnel. Therefore, additional personal protective equipment may be warranted in lieu of vaccination. For personnel who have no neutralizing antibody titer (either by previous vaccination or natural infection), additional respiratory protection is recommended for all procedures.

[87]According to the ACIP, no data are available on the risk of yellow fever for pregnant or breastfeeding women and their fetuses or infants. However, on the basis of surveillance and outbreak data, pregnant and breastfeeding women do not appear to be at risk for more severe yellow fever disease. The BMBL recommends HEPA-filtered lab exhaust for laboratories conducting work with the yellow fever virus.

[88]Vaccines are available for immunization against yellow fever. It is recommended for all personnel who work with this agent or with infected animals, and those entering rooms where the agents or infected animals are present.