Postexposure prophylaxis for occupational exposure to selected pathogens for healthcare personnel

Alison Han[a] *and David K. Henderson*[b]

Purpose of review
Timely postexposure prophylaxis is important after an occupational exposure. Here we review select organisms, exposure opportunities in the healthcare setting, and postexposure prophylaxis regimens.

Recent findings
Needlestick injuries pose a risk of exposure to bloodborne pathogens, such as HIV, Hepatitis B, and Hepatitis C. Risk mitigation strategies should be reexamined in light of newer vaccines and therapeutics. Increased vaccine hesitancy and vaccine denialisms may foster the re-emergence of some infections that have become extremely uncommon because of effective vaccines. With increasing occurrences of zoonotic infections and the ease of global spread as evidenced by COVID-19 and mpox, healthcare exposures must also consider risks related to emerging and re-emerging infectious diseases.

Summary
Early recognition and reporting of occupational exposures to pathogens with available postexposure prophylaxis is key to mitigating the risk of transmission. Providers should be able to evaluate the exposure and associated risks to provide prompt and appropriate postexposure prophylaxis.

Keywords
needlestick, occupational health, postexposure prophylaxis

INTRODUCTION

Occupational exposures to pathogens unfortunately occur relatively commonly in the healthcare workplace. The purpose of this paper is to address current postexposure interventions known to be effective in mitigating the risk for transmission of selected pathogens following occupational exposures in the healthcare workplace.

The management of these exposures lies primarily in the purview of the occupational medicine team in any healthcare facility; however, some institutions lack a 24-h presence for occupational medicine, and, in such institutions, the emergency department often assumes this role. Often, the healthcare epidemiology team and infectious diseases consultants also will be called on to provide expertise in managing occupational exposures in the healthcare setting.

One of the most challenging issues is determining whether an exposure has occurred. Curiously, this may be the most difficult determination in postexposure management. Accordingly, we have attempted to provide information about exposures for the relevant pathogens. The paper is organized by pathogen, routes of exposure, approaches to postexposure prophylaxis, and recent developments with respect to each pathogen. Current approved prophylactic regimens are outlined in Table 1.

BACTERIAL DISEASES

Meningococcal disease

Exposure – Healthcare personnel (HCP) may become exposed by having direct, close contact with

[a]Hospital Epidemiology Service, Clinical Center, National Institutes of Health Service and [b]Hospital Epidemiology Service, National Institutes of Health Clinical Center, Bethesda, Maryland, USA

Correspondence to David K. Henderson, MD, Senior Consultant, Hospital Epidemiology Service, National Institutes of Health Clinical Center, Room 9D46A 10 Center Drive, Bethesda, MD 20892, USA.
Tel: +1 301 496 2209; e-mail: dkh@nih.gov

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KEY POINTS

- Postexposure prophylaxis for occupational exposures to infectious diseases in the healthcare workplace is a key component of occupational medicine in healthcare settings; staff need to be informed of and the risks for, management of, and postexposure treatment for pathogens commonly encountered in the healthcare workplace.
- In light of the steady increase in the prevalence in the United States of vaccine hesitancy and vaccine denialism, healthcare professionals should be vigilant about the possible reappearance of pathogens such as diphtheria, pertussis and tetanus for which effective postexposure prophylaxis interventions exist.
- Determining whether an exposure has occurred is often challenging and timing of prophylaxis is critical; in general, prophylaxis should be administered as soon as possible once an exposure determination has been made.
- Pathogens are prone to develop resistance to commonly used agents over time; staying current with public health recommendations is key to successful postexposure interventions.
- Whereas potentially effective agents may exist for postexposure prophylaxis to some pathogens, in some instances, low rates of transmission and highly effective, curative therapies may argue for monitoring and early therapy, rather than immediate postexposure prophylaxis (e.g., hepatitis C).

mucous membranes or secretions from a patient who has documented meningococcal disease (e.g., such as by providing mouth-to-mouth resuscitation or inserting or manipulating an endotracheal tube while not wearing appropriate personal protective equipment). Lesser contact with an infected patient (e.g., being in the same room, same hallway, or having encounters other than face-to-face, delivering meals, or even performing a history and physical) is not classified as an exposure. Additionally, having unprotected direct contact with respiratory secretions or saliva of a person who is colonized with *N. meningitidis*, but who does not have clinical disease, also is not considered an exposure.

Prophylaxis – according to the Centers for Disease Control and Prevention (CDC), chemoprophylaxis with rifampin (600 mg every 12 h for 48 h), ceftriaxone (250 mg intramuscularly) or ciprofloxacin (500 mg orally), are between 90% and 95% effective in eradicating nasopharyngeal carriage of *N. meningitidis* [1,2]. Azithromycin is an acceptable alternative when one anticipates ciprofloxacin-resistance [3▪].

Newer developments – though not directly related to postexposure prophylaxis, the past year has seen the Food and Drug Administration (FDA) approval [4] and Advisory Committee on Immunization Practices (ACIP) endorsement [5▪] of a new pentavalent conjugate vaccine for individuals 10–25 years of age that provides immunoprophylaxis coverage for meningococcal serogroups ABCW and Y. The vaccine received FDA approval in October 2023 and was endorsed by the ACIP later that October. In addition, because of increasing ciprofloxacin resistance, CDC issued new prophylaxis guidelines that suggest the use of rifampin, ceftriaxone, or azithromycin instead of ciprofloxacin when two or more ciprofloxacin-resistant meningococcal disease cases are reported in a defined area [3▪].

Anthrax

Exposure – HCP may become exposed by handling cutaneous lesions without appropriate personal protective equipment (PPE). Concern has also been expressed for inhalation exposure due to bioterrorism.

Prophylaxis – Recently issued CDC guidelines provide evidence for antimicrobial prophylaxis efficacy [6]. Current FDA-approved agents for prophylaxis are: doxycycline (100 mg orally every 12 h), ciprofloxacin (500 mg orally every 12 h) and levofloxacin (500 mg orally every 24 h). The appropriate duration of postexposure prophylaxis is unknown, but because spores persist for extended periods of time, the current recommendation is for at least 7 days of prophylaxis for cutaneous exposure and at least 60 days of prophylaxis for inhalation exposures. In addition, in the past few years both monoclonal (Obiltoxaximab and Raxibacumab) and polyclonal (anthrax immunoglobulin intravenous) antitoxins have become available. The polyclonal product is harvested from the sera of individuals who have been immunized with anthrax vaccine. The antitoxins have demonstrated efficacy in animal models, but are not quite as effective as antimicrobials. If effective antimicrobials are not available, the antitoxins offer a reasonable alternative.

Newer developments – New candidate vaccines have shown promise in animal studies in the past 18 months [7,8] and CDC issued a revised and updated set of guidelines for the prevention and treatment of anthrax in late 2023 [6].

Diphtheria

Exposure – Diphtheria transmission occurs through direct contact with respiratory secretions (or, if the

Table 1. Recommended postexposure prophylaxis for occupational exposure to selected pathogens

Organism	Modes of transmission	Status of HCP	PEP	Notes
Bacteria				
Neisseria meningitidis	Droplet	Regardless of immunization status if managing an airway or direct contact with respiratory secretions within 7 days of symptom onset	• Rifampin 600 mg p.o. every 12 h × 48 h • Ceftriaxone 250 mg i.m. × 1 • Ciprofloxacin[a] 500 mg p.o. × 1 • Azithromycin[b] 500 mg p.o. × 1	• Rifampin: review drug interactions • Rifampin, Ciprofloxacin: Not for pregnant women
Anthrax	Contact	Direct contact with cutaneous lesions	• Doxycycline 100 mg p.o. every 12 h • Ciprofloxacin 500 mg p.o. every 12 h • Levofloxacin 500 mg p.o. every 24 h	• Cutaneous: ≥ 7 days • Inhalation: ≥ 60 days • Consider antitoxin if no antimicrobials are available
Diphtheria	Droplet, Contact	Direct contact with respiratory secretions or cutaneous lesions	• Diphtheria vaccine • Benzathine penicillin G 1.2 million units i.m. × 1 • Erythromycin 250 mg p.o. every 6 h × 7–10 days	• Depends on vaccination status
Pertussis	Droplet	Regardless of immunization status after direct contact with respiratory secretions	• Azithromycin 500 mg × 1 on Day 1, then 250 mg p.o. daily Days 2–5 • Erythromycin 500 mg p.o. every 6 h × 10 days • Clarithromycin 500 mg p.o. every 12 h × 7 days • Trimethoprim 160 mg/sulfamethoxazole[c] 800 mg p.o. every 12 h × 14 days	
Viruses				
HIV	Bloodborne	Parenteral exposure to blood or splashes of blood into mucous membranes	• Raltegravir 400 mg p.o. twice a day AND • Tenofovir disoproxil fumarate 300 mg p.o. daily AND • Emtricitabine 200 mg p.o. daily	
HBV	Bloodborne	Parenteral exposure to blood or splashes of blood into mucous membranes	• Hepatitis B vaccine • HBIG 0.06 mL/kg	• Depends on vaccination status and response to vaccinations
Influenza	Droplet	Large droplets within 6 feet or indirect contact from a contaminated surface or object	• Oseltamivir 75 mg p.o. daily × 7 days • Zanamivir 10 mg (two 5-mg inhalations) daily × 7 days • Baloxavir 40 mg p.o. × 1 (if weight < 80 kg) or 80 mg p.o. × 1 (if weight ≥ 80 kg)	• Depends on underlying medical conditions and vaccine status and anticipated response to vaccination • For PEP after exposure to avian influenza, twice a day dosing for oseltamivir or zanamivir
Mpox	Contact	Contact with patient's lesions, bodily fluids, respiratory secretions, or contaminated environment	• JYNNEOS • ACAM2000	
Rabies	Contact	Bite or contact between a patient's saliva and a person's mucous membranes or broken skin	• HDCV • PCECV • HRIG 20 international units/kg	
VHF	Contact	Contact with patient's blood, bodily fluids, respiratory secretions, or contaminated environment	• None	
Parasites				
Malaria	Bloodborne	Parenteral exposure to blood or splashes of blood into mucous membranes	• None	• Consult with Occupational Health and Infectious Diseases

i.m., intramuscular; KG, kilogram; PEP, postexposure prophylaxis; p.o., *per os* (by mouth).
[a]If no fluoroquinolone-resistant strains identified in the community.
[b]Alternative if sustained fluoroquinolone-resistant strains identified in the community.
[c]Alternative if macrolide allergy or if known macrolide-resistant strain.

patient has cutaneous disease, direct contact with lesions, wounds, or skin exudate) from a patient infected with *Corynebacterium diphtheriae*. For HCP, diphtheria exposure is defined as unprotected (i.e., the HCP was not wearing appropriate PPE), close, face-to-face contact with an infected patient or the patient's secretions [9].

Prophylaxis – Postexposure prophylaxis for occupational diphtheria exposures includes the administration of a dose of diphtheria vaccine as

well as the administration of either a single dose of benzathine penicillin G (1.2 million units intramuscularly) or a 10-day course of oral erythromycin (250 mg every 6 hours) [9].

Newer developments – Substantial outbreaks of diphtheria have occurred during the past 18 months in Nigeria [10▪], Pakistan [11], and Australia [12].

Pertussis

Exposure – Direct face-to-face contact with an infected person (while not wearing appropriate PPE) or contact with secretions from an infected individual constitutes exposure to pertussis.

Prophylaxis – Since immunity to pertussis is known to wane over time, postexposure prophylaxis for occupational pertussis exposures should be administered to all exposed providers. Acceptable agents for prophylaxis include: azithromycin (a 500 mg first dose, followed by 250 mg orally per day for 5 days); erythromycin (500 mg orally every 6 h for 10 days); clarithromycin (500 mg orally every 12 h for 7 days); or trimethoprim-sulfamethoxazole (160 mg trimethoprim/800 mg sulfamethoxazole every 12 h for 14 days) [13].

Newer Developments – The last 18 months have seen the development and testing of vaccines designed to produce mucosal immunity to pertussis [14▪▪,15], but the duration of protection for the new vaccines is unknown. Pertussis immunity in healthcare personnel remains a concern around the world. Most recently, a large study of pertussis immunity in China found that >57% of healthcare workers had no immunoglobulin G (IgG) directed against *Bordetella pertussis* [16▪].

VIRAL DISEASES

Human immunodeficiency virus (HIV)

Exposure – Healthcare-associated occupational exposures to HIV are most commonly associated with parenteral exposures to blood or other blood-containing fluids from patients infected with HIV. In addition, splashes of blood or blood-containing fluids onto mucous membranes are also considered occupational exposures. Exposures of intact skin to such materials are not considered an exposure.

Prophylaxis – Numerous animal studies, studies of postpartum prophylaxis and a retrospective case-control study published by CDC in the late 1990s [17] all suggest efficacy of postexposure antiretroviral chemoprophylaxis for occupational HIV exposures. The most recently published guidelines published in 2013 [18▪] recommend a combination of raltegravir (400 mg orally twice daily) plus tenofovir disoproxil fumarate (300 mg orally once daily) plus emtricitabine (200 mg orally once daily). (The tenofovir disoproxil fumarate and emtricitabine are available as one pill – Truvada). Several possible alternative regimens are provided.

Newer developments – The CDC's postexposure prophylaxis guidelines are currently under revision. The new guidelines will take into consideration the many new, improved, and less-toxic antiretroviral agents and combination pills that have become available since the previous guidelines were written. Although no definitive recommendations have been published, we anticipate that the updated guidelines will recommend an integrase strand transfer inhibitor plus two nucleotide/nucleoside reverse transcriptase inhibitors. Newer preparations combine all three agents into one pill. The new guidance is also likely: to emphasize the administration of antiretroviral postexposure prophylaxis as soon as practical following an HIV occupational exposure; to suggest that exposed staff should receive counseling and testing for HIV, hepatitis B and hepatitis C as soon as possible after the exposure to establish baselines; to emphasize that exposed staff should be reevaluated within 72 h of the exposure and should be monitored regularly for drug toxicity during the course of treatment; to advocate that, when possible, testing should employ fourth generation HIV antigen/antibody tests at baseline, when any symptoms consistent with acute infection occur, and at three months following the exposure; to suggest that qualitative nucleic acid tests also be performed at the completion of therapy (i.e., three months following the exposure).

Hepatitis B virus (HBV)

Exposure – As is the case for both HIV and HCV, healthcare-associated occupational exposures to HBV are most commonly associated with parenteral exposures to blood or other blood-containing fluids from patients infected with HIV. In addition, splashes of blood or blood-containing fluids onto mucous membranes are also considered occupational exposures. Exposures of intact skin to such materials are not considered an exposure.

Prophylaxis – Prior to the development of the hepatitis B vaccine, hepatitis B was a major occupational hazard for healthcare personnel whose jobs entail handling or processing blood or blood-containing materials. Serologic studies of healthcare personnel and controls conducted in the 1970s suggested that healthcare personnel were at a ten-fold increased risk for hepatitis B infection. In 1991 the Department of Labor's Occupational Safety and Health Administration published its Bloodborne

Pathogen Standard that required all healthcare employers to offer HBV vaccine to all employees at risk for exposure to blood or blood-containing fluids. This requirement combined with the immunization of mothers and their infants has had a marked effect on the epidemiology of HBV in the United States. According to CDC, HBV infection among healthcare personnel declined by 98% from 1983 to 2010 [19]. Nonetheless healthcare personnel who have not been immunized, those who fail to respond to immunization and some of those whose antibody titers have become undetectable are at risk. Vaccine nonresponders (i.e., a provider who fails to respond to six doses of the vaccine) who have documented exposure should be given two doses of hepatitis B immune globulin (HBIG) 0.06 ml/kg, with one month between the doses. Postexposure prophylaxis for providers who have received three doses of vaccine, but their antibody status is unknown should immediately be tested for antibody to hepatitis B surface antigen (anti-HBs). If the provider has >10 mIU/ml, no further treatment is needed; if <10 mIU/ml, the provider should be given one dose of HBIG (0.06 ml/kg), followed by the traditional three dose vaccine series (at 0, 1 and 6 months). Unvaccinated or incompletely vaccinated providers who have exposure should receive a dose of HBIG (0.06 ml/kg) followed by the three dose vaccine series. Providers who receive HBIG prophylaxis should receive baseline tests for HBV infection as soon as possible after exposure, and follow-up testing approximately 6 months later. At baseline, these providers should be tested for antibody directed at the hepatitis B core antigen (anti-HBc) and tested again if symptoms develop or at 6 months following the exposure for both hepatitis B surface antigen (HBs) as well as for antibody to HBc.

Newer developments – The past decade has seen the development and licensing of several antivirals capable of suppressing HBV (e.g., entecavir, tenofovir alafenamide, tenofovir disoproxil fumarate, lamivudine, and adefovir). Although these agents have been used successfully in preventing the relapse of HBV infection in immunosuppressed patients, they are not recommended for postexposure prophylaxis for occupational exposures.

Influenza

Exposure – Exposure to influenza virus occurs via large droplets (e.g., coughing, sneezing, talking) typically over distances <6 ft. Indirect contact transmission also occurs by hand transfer via a contaminated surface or object to a person's facial mucosal surface (e.g., nose, mouth). Airborne transmission via small droplets may also occur, though this is not known to occur over longer distances [20].

Prophylaxis – Several antivirals are available for postexposure prophylaxis, including oral oseltamivir, inhaled zanamivir, and oral baloxavir [21▪▪]. Postexposure prophylaxis can be considered for HCP who are at high risk for complications from influenza infection and in whom influenza vaccine is contraindicated or anticipated to have low effectiveness [22]. It is recommended all HCP receive influenza vaccine annually unless they have a medical contraindication [23,24].

Newer developments – With ongoing outbreaks of highly pathogenic avian influenza (HPAI) A virus infection in animals, occasional animal-to-human transmission, and the known pandemic potential, HCP must be on high alert when caring for patients who are in close contact with infected animals. Patients suspected or confirmed to have HPAI infection should be placed on airborne and contact precautions with eye protection. For chemoprophylaxis after exposure to avian influenza, twice a day dosing of oseltamivir or zanamivir is recommended over daily dosing [25▪▪]. Due to concerns of novel influenza A oseltamivir-resistance, treatment with zanamivir or baloxavir should be considered in persons who become symptomatic after chemoprophylaxis with osteltamivir [25▪▪].

Mpox

Exposure – CDC recommends postexposure prophylaxis for risk levels of exposure that are intermediate or high. An intermediate exposure includes unprotected contact with a patient (e.g., contact with a patient's skin lesions or bodily fluids, contact with a patient's soiled materials, or unmasked within 6 ft for a total of 3 or more cumulative hours). A higher risk level of exposure is if the exposure occurs to the person's broken skin or mucous membranes (e.g., eyes, mouth) or being in the room during an aerosol-generating procedure or resuspension of dried exudates (e.g., shaking of soiled linens) without wearing appropriate PPE [26▪].

Prophylaxis – Two vaccines, ACAM2000 and JYNNEOS are available for PEP. ACAM2000 is approved in the United States for smallpox, but available under an Expanded Access Investigational New Drug (EA-IND) protocol. JYNNEOS is approved for smallpox and mpox. It is currently being distributed by the Administration for Strategic Preparedness & Response (ASPR), but the company plans for commercial distribution in 2024.

Newer developments – Cases from the global outbreak of mpox that began in 2022 [27] continue. In addition, Democratic Republic of Congo is

currently experiencing its largest outbreak affecting many of its provinces including the capital city of Kinshasa (https://emergency.cdc.gov/han/2023/han00501.asp).

Rabies

Exposure – Healthcare setting exposure of rabies virus could occur after a bite by an infected patient or contact between the patient's saliva and a person's mucous membranes (e.g., eyes, mouth) or broken skin. Exposure to wildlife on the premises of a healthcare facility is also possible. Caring for a patient with rabies does not meet criteria for an exposure.

Prophylaxis – For previously unvaccinated persons, a single dose of human rabies immune globulin (HRIG) (20 international units/kilogram body weight) should be administered [28]. Previously unvaccinated persons should also receive four doses of rabies vaccine, human diploid cell culture rabies vaccine (HDCV) or purified chick embryo cell culture rabies vaccine (PCECV). Previously vaccinated persons should receive two doses of HDCV or PCECV [29,30].

Newer developments – ACIP provided updated guidance for preexposure prophylaxis in May 2022, including two-dose rabies vaccination replacing the previous three-dose schedule [31]. While intradermal (or intramuscular) vaccination is recommended by WHO [32], rabies vaccines in the United States are only approved for intramuscular administration [33]. Studies have also evaluated a potential one-dose rabies vaccination for preexposure prophylaxis [34]. Monoclonal antibodies have potential for PEP [35,36].

Viral hemorrhagic fevers (e.g., Ebola, Marburg, Lassa, Crimean Congo Hemorrhagic Fever, the South American Hemorrhagic Fevers)

Exposure – Healthcare setting exposures to viral hemorrhagic fevers (VHF) result from contact with the blood or body fluids of a patient or, in some instances, with the contaminated patient-care environment.

Prophylaxis – No products are currently approved for postexposure prophylaxis after exposure to the viruses causing VHF. Two approved vaccines are available for Ebola preexposure prophylaxis, and some animal studies have suggested possible efficacy when used for postexposure prophylaxis; however, a more recently conducted macaque study failed to demonstrate improved outcomes associated with the postexposure administration of vesicular stomatitis virus-Ebola virus vaccine [37]. Animal studies have also demonstrated efficacy of monoclonal antibodies raised against Ebola targets, though these data have not been replicated in human studies. Though ribavirin has long been considered for the treatment and postexposure prophylaxis of some VHF, including Crimean Congo hemorrhagic fever; it is not formally approved nor recommended by CDC for postexposure prophylaxis.

Newer developments – The COVID-19 pandemic stimulated a major effort in antiviral drug development. Several studies of repurposed antivirals or monoclonal antibodies are in development for several of the agents of VHF. One promising compound is obeldesivir, demonstrated in animal studies to be 100% protective when administered as postexposure prophylaxis against Ebola, Marburg, and Sudan virus [38▪▪].

PARASITIC DISEASES

Malaria

Exposure – While transmission typically occurs via mosquitos, healthcare exposures may occur after exposure to blood likely through parenteral exposure [39,40].

Prophylaxis – There is no standard regimen for postexposure prophylaxis for healthcare exposures to malaria; administration of effective antimalarial agents following a documented parenteral occupational exposure may be considered after consultation with occupational health and infectious diseases.

Newer developments – In 2021, the first malaria vaccine was recommended by the World Health Organization (WHO) and currently two are recommended: RTS,S/AS01 and R21/Matrix-M. As yet, no malaria vaccine has been approved by the FDA. In the United States, locally acquired malaria, while uncommon, has occurred as recently as 2023 [41▪].

CONCLUSION

Substantial progress has been made in the four decades since postexposure prophylaxis for occupational exposures to HIV was initially offered. Assuring that staff are fully informed about the risks for occupational exposure and that they are aware the actions to take should such an exposure occur; making certain that access to Occupational Medicine/Employee Health is readily available; and making certain that exposures are managed in a timely, scientifically based manner are the key components of effective postexposure management strategies in

the healthcare setting. New agents and vaccines and more studies of safety and efficacy are needed to establish effective postexposure interventions for a variety of pathogens for which no approved interventions exist.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

1. Centers for Disease Control and Prevention. Meningococcal Disease: Infection Control in Healthcare Personnel: Epidemiology and Control of Selected Infections Transmitted Among Healthcare Personnel and Patients Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated November 2, 2022; cited 3/21/2024]. Available at: https://www.cdc.gov/infectioncontrol/guidelines/healthcare-personnel/selected-infections/meningococcal-disease.html.
2. McNamara L, Blain, A. Manual for the Surveillance of Vaccine-Preventable Diseases: Chapter 8: Meningococcal Disease. Atlanta, GA: Centers for Disease Control and Prevention; 2024 [updated 1/5/2022. Available at: https://www.cdc.gov/vaccines/pubs/surv-manual/chpt08-mening.html.
3. ■ Berry I, Rubis AB, Howie RL, *et al.* Selection of antibiotics as prophylaxis for close contacts of patients with meningococcal disease in areas with ciprofloxacin resistance – United States, 2024. MMWR Morb Mortal Wkly Rep 2024; 73:99–103.

An important notice about the presence of increasing ciprofloxacin resistance among meningococci in selected areas of the US.

4. Food and Drug Administration. Penbraya Washington, DC: U.S. Department of Health and Human Services; 2024 [updated 11/27/2023; cited 4/2/2024]. Available at: https://www.fda.gov/vaccines-blood-biologics/vaccines/penbraya.
5. ■ Murthy N, Wodi AP, McNally VV, *et al.* Advisory committee on immunization practices recommended immunization schedule for adults aged 19 years or older – United States. MMWR Morb Mortal Wkly Rep 2024; 73:11–15.

The CDC's Advisory Committee on Immunization Practices' recommendations for people 19 years of age or older that includes the first recommendation for the use of the pentavalent meningococcal vaccine.

6. Bower WA, Yu Y, Person MK, *et al.* CDC guidelines for the prevention and treatment of anthrax. MMWR Recomm Rep 2023; 72:1–47.
7. Kim GL, Pyo SW, Yi H, *et al.* Immunogenicity and protective efficacy of recombinant protective antigen anthrax vaccine (GC1109) in A/J mice model. Vaccine 2023; 41:3106–3110.
8. Henning L, Anderson M, Triplett C, *et al.* Efficacy of different AV7909 dose regimens in a nonclinical model of pulmonary anthrax. Hum Vaccin Immunother 2023; 19:2290345.
9. Centers for Disease Control and Prevention. Diphtheria: Infection Control in Healthcare Personnel: Epidemiology and Control of Selected Infections Transmitted Among Healthcare Personnel and Patients [11-2-2022]. Atlanta, GA: U.S. Department of Health and Human Services; 2022. Available at: https://www.cdc.gov/infectioncontrol/guidelines/healthcare-personnel/selected-infections/diphtheria.html#anchor_1635880478118.
10. ■ Omosigho PO, John OO, Adigun OA, *et al.* The re-emergence of diphtheria amidst multiple outbreaks in nigeria. Infect Disord Drug Targets 2023.

A review of the status of the re-emergence of diphtheria in India. The paper discusses the several outbreaks that have occurred over the past two years and ascribes the occurrence of these outbreaks to deficiencies in in routine immunization practices., the occurrence of other nationwide epidemics, and insufficient awareness of diphtheria in Nigeria.

11. Aaqil SI, Ochani S, Hasibuzzaman MA. Recent outbreak of diphtheria in Pakistan; short communication. Ann Med Surg (Lond) 2023; 85:3243–3244.
12. Hempenstall A, Short J, Marquardt T, *et al.* Clinician alert: toxigenic diphtheria cases across North Queensland are on the rise. Med J Aust 2023; 218:238.
13. Tiwari T, Murphy TV, Moran J, National Immunization Program, CDC. Recommended antimicrobial agents for the treatment and postexposure prophylaxis of pertussis: 2005 CDC Guidelines. MMWR Recomm Rep 2005; 54:1–16.
14. ■■ Keech C, Miller VE, Rizzardi B, *et al.* Immunogenicity and safety of BPZE1, an intranasal live attenuated pertussis vaccine, versus tetanus-diphtheria-acellular pertussis vaccine: a randomised, double-blind, phase 2b trial. Lancet 2023; 401:843–855.

This report describes the safety and immunogenicity of a novel, intranasally administered pertussis vaccine that has been designed to induce mucosal immunity. This Phase 2 trial demonstrated both serum and mucosal immunity. following immunization and consistently produced IgA antibody, compared with the standard tDAP immunization. Follow-up was insufficient to determine the durability of the response.

15. Edwards KM, Decker MD. An alternative route to pertussis protection? Lancet 2023; 401:800–801.
16. ■ Shi W, Wang B, Meng Q, *et al.* Seroprevalence of tetanus and pertussis antibodies among healthcare workers in Wuhu, China. Hum Vaccin Immunother 2024; 20:2318892.

This study demonstrated that the majority of HCP in Chin lack protective antibody against both tetanus and pertussis and recommends routine booster immunization for both diseases for all Chinese healthcare providers.

17. Cardo DM, Culver DH, Ciesielski CA, *et al.* A case-control study of HIV seroconversion in healthcare workers after percutaneous exposure. Centers for Disease Control and Prevention Needlestick Surveillance Group. N Engl J Med 1997; 337:1485–1490.
18. ■ Kuhar DT, Henderson DK, Struble KA, *et al.* Updated US Public Health Service guidelines for the management of occupational exposures to human immunodeficiency virus and recommendations for postexposure prophylaxis. Infect Control Hosp Epidemiol 2013; 34:875–892.

Current Centers for Disease Control and prevention guidelines for managing occupational exposure to HIV; these recommendations will likely be updated in 2024.

19. Schillie S, Murphy TV, Sawyer M, *et al.* CDC guidance for evaluating healthcare personnel for hepatitis B virus protection and for administering postexposure management. MMWR Recomm Rep 2013; 62:1–19.
20. Centers for Disease Control and Prevention. Influenza (Flu): Prevention Strategies for Seasonal Influenza in Healthcare Settings Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 5/13/2021; cited 2024 4/1/2024]. Available at: https://www.cdc.gov/flu/professionals/infectioncontrol/healthcaresettings.htm.
21. ■■ Centers for Disease Control and Prevention. Influenza (Flu): Influenza Antiviral Medications: Summary for Clinicians Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 12/8/2023; cited 2024 4/1/2024]. Available at: https://www.cdc.gov/flu/professionals/antivirals/summary-clinicians.htm.

Current US Public Health Service guidance for the use of antiviral medications for influenza.

22. Uyeki TM, Bernstein HH, Bradley JS, *et al.* Clinical practice guidelines by the Infectious Diseases Society of America: 2018 update on diagnosis, treatment, chemoprophylaxis, and institutional outbreak management of seasonal influenza. Clin Infect Dis 2019; 68:e1–e47.
23. Pearson ML, Bridges CB, Harper SA. Influenza vaccination of health-care personnel: recommendations of the Healthcare Infection Control Practices Advisory Committee (HICPAC) and the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2006; 55(Rr–2):1–16.
24. Immunization of health-care personnel: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep. 2011;60:1–45.
25. ■■ Centers for Disease Control and Prevention. Avian Flu: Healthcare & Laboratorian Guidance, Interim Guidance on Follow-up of Close Contacts of Persons Infected with Novel Influenza A Viruses and Use of Antiviral Medications for Chemoprophylaxis Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 3/25/2022; cited 2024 4/1/2024]. Available at: https://www.cdc.gov/flu/avianflu/novel-av-chemoprophylaxis-guidance.htm.

Latest Public Health Service guidelines for management of exposure to highly pathogenic avian influenza and other novel influenza viruses.

26. ■ Centers for Disease Control and Prevention. Mpox: Infection Prevention and Control of Mpox in Healthcare Settings Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 10/31/2022; cited 2024 4/2/2024]. Available at: https://www.cdc.gov/poxvirus/mpox/clinicians/infection-control-healthcare.html.

Updated Public Health Service guidance about the management of exposures to Mpox.

27. McQuiston JH, Braden CR, Bowen MD, *et al.* The CDC domestic mpox response – United States, 2022-2023. MMWR Morb Mortal Wkly Rep 2023; 72:547–552.
28. Centers for Disease Control and Prevention. Rabies: Human Rabies Immune Globulin Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 4/22/2011; cited 2024 4/12/2024]. Available at: https://www.cdc.gov/rabies/medical_care/hrig.html.
29. Rupprecht CE, Briggs D, Brown CM, *et al.* Use of a reduced (4-dose) vaccine schedule for postexposure prophylaxis to prevent human rabies: recommendations of the advisory committee on immunization practices. MMWR Recomm Rep 2010; 59:1–9.

30. Centers for Disease Control and Prevention. Rabies: Rabies Vaccine Atlanta, GA: U.S. Department of Health and Human Services; 2024 [updated 9/24/2014; cited 2024 4/12/2024]. Available at: https://www.cdc.gov/rabies/medical_care/vaccine.html.
31. Rao AK, Briggs D, Moore SM, *et al.* Use of a modified preexposure prophylaxis vaccination schedule to prevent human rabies: recommendations of the advisory committee on immunization practices – United States, 2022. MMWR Morb Mortal Wkly Rep 2022; 71:619–627.
32. O'Brien KL, Nolan T. The WHO position on rabies immunization – 2018 updates. Vaccine 2019; 37(Suppl 1):A85–A87.
33. Centers for Diseases Control and Prevention. In: Nemhauser JB, editor. CDC Yellow Book 2024: Health Information for International Travel. Oxford University Press; 2023.
34. Damanet B, Costescu Strachinaru DI, Levêque A. Single visit rabies preexposure prophylaxis: a literature review. Travel Med Infect Dis 2023; 54:102612.
35. de Melo GD, Hellert J, Gupta R, *et al.* Monoclonal antibodies against rabies: current uses in prophylaxis and in therapy. Curr Opin Virol 2022; 53:101204.
36. Fan L, Zhang L, Li J, Zhu F. Advances in the progress of monoclonal antibodies for rabies. Hum Vaccin Immunother 2022; 18:2026713.
37. Bushmaker T, Feldmann F, Lovaglio J, *et al.* Limited benefit of postexposure prophylaxis with VSV-EBOV in Ebola virus-infected rhesus macaques. J Infect Dis 2023; 228(Suppl 7):S721–S729.
38. ■■ Cross RW, Woolsey C, Chu VC, *et al.* Oral administration of obeldesivir protects nonhuman primates against Sudan ebolavirus. Science 2024; 383: eadk6176.
One example of antiviral drug development for COVID, Obeldesivir a prodrug of remdesivir and one of its metabolites show similar *in vitro* antiviral activity against filoviruses, (Marburg, Ebola, and Sudan viruses).
39. Tarantola AP, Rachline AC, Konto C, *et al.* Occupational malaria following needlestick injury. Emerg Infect Dis 2004; 10:1878–1880.
40. Alweis RL, DiRosario K, Conidi G, *et al.* Serial nosocomial transmission of Plasmodium falciparum malaria from patient to nurse to patient. Infect Control Hosp Epidemiol 2004; 25:55–59.
41. ■ Blackburn D, Drennon M, Broussard K, *et al.* Outbreak of locally acquired mosquito-transmitted (Autochthonous) Malaria – Florida and Texas, May–July 2023. MMWR Morb Mortal Wkly Rep 2023; 72:973–978.
Public health report describing an outbreak of malaria that occurred in Texas and Florida.