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Immunizations and oral health care providers

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Oral health care workers may be exposed to a variety of infectious agents as they carry out their professional responsibilities. This article discusses issues facing the dental health care provider relative to immunization. Advantages and disadvantages of immunizations for oral health care professionals are addressed. Because of exposure to bloodborne and airborne pathogens, dentists are at risk for contracting diseases from and transmitting diseases to their patients (Table 1). Dentists must recognize diseases that are most commonly transmitted in dental offices.

Two very successful approaches aimed at preventing infectious diseases acquired in the dental office have introduced more vigilant infection control and barrier techniques as well as the use of specific immunizations. Special consideration will be given to the subgroup of dental professionals at increased risk for common diseases that may prevail because of the location and demographics of their practices. A brief review of the basic principles of immunology and immunization is covered as well as immunizations and the medically compromised oral health care worker, the medically compromised patient, new vaccines that may be in the offing, and the future role of immunization for dentists.

Immunizations and the immune system

The immune system comprises organs, cells, and molecules dedicated to the identification and destruction of foreign (nonhost organism) substances or cells that have the potential for harming the host. This defense system is derived primarily from antibodies and white blood cells. It can be specific or nonspecific in its response mode [1].

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Table 1
Occupationally acquired infections resulting from airborne and bloodborne transmission

Infection	Attack rate (%)[a]	Health care workers most affected
Airborne transmission		
Tuberculosis	20 to 50	Nurses, pathologists, laboratory workers, housekeepers
Varicella	4.4 to 14.5	All
Measles	NA	Physicians, nurses
Influenza	3.8 to 45	Nurses, physicians
Rubella	13	All
Mumps	NA	Pediatricians, dentists
Pertussis	43	All
Parvovirus	27 to 47	Nurses
Respiratory syncytial virus	42 to 56	All
Andenovirus	22 to 39	Workers in ophthalmology clinics, intensive care units, long-term care facilities
Bloodborne transmission		
Human Immunodeficiency virus	0.1 to 0/4 (per needle stick)	Nurses, laboratory workers
Hepatitis B	2[b] to 20 to 40[c]	Nurses, laboratory workers, surgeons, dentists, dialysis unit workers
Hepatitis C	1.2 to 10.0 (per needle stick)	Oral surgeons
Cytomegalovirus	Very low	None
Ebola virus	High	Nurses
Simian B virus	High	Animal handlers
Creutzfeldt-Jakob disease	NA	None

[a] For airborne transmission, the attack rates are as reported for outbreaks; for bloodborne transmissions, exposure-associated attack rates are given.
[b] In those who are positive for hepatitis B early antigen.
[c] In those who are positive for hepatitis B early antigen.
Adapted from Depkowitz KA. Occupationally acquired infections in health care workers. Part I. Ann Intern Med 1996;125:826–34; with permission.

Eosinophils, neutrophils, and monocytes are phagocytic white blood cells that engulf and destroy invading organisms via phagocytosis. These cells respond to all nonhost invaders and are providers of nonspecific immunity. Lymphocytes are white blood cells that can develop specific memory for molecular and morphologic structures of adaptive pathogens [2]. They constitute the specific immune system [3]. The specific immune system constitutes lymphocytic T-cells or B-cells. The T-cells are so designated because their development is mediated by the thymus gland. The development and maturation of B-cells is thought to be linked to the bone marrow [2,3].

B-cells secrete antibodies to intercept and destroy invading organisms. Because this involves production of defensive substances for the host, the

B-cells are said to be involved in humoral immunity. The functions of the various antibodies such as IgM, IgE, IgA, and IgG reduce the morbidity associated with infectious diseases by limiting the initial infection via reduction of bacteremia or viremia [4].

T-cells constitute a branch of the immune system called cell-mediated immunity. T-cells can develop memory, at the molecular level, to the morphology of invading agents (antigens). This enables the host defense mechanism to react later in a more efficient manner to the same antigen [2]. The T-cell can act as a surveillance unit and will communicate with and control the actions of other immune cells. This results in both the B-cells and the T-cells retaining the ability to respond with efficiency to previously encountered specific antigens [3].

Infectious organisms, usually in the form of bacteria, viruses, fungi, or parasites, can enter the body, multiply, and cause infection. Each of these agents has a recognizable morphology giving each of them specific antigen status. The specific immune system continually confronts intruding organisms and is constantly forming a response in the form of specific antibodies directed at that specific organism. The specific immune system can eventually destroy invading pathogens, and the host defense retains the ability from this exposure to more efficiently and rapidly produce new antibodies to this particular antigen in future encounters. This type of response is called active immunity [5]. During an initial encounter with an invading organism, active immunity works well for the host as long as the pathogens do not have a high degree of virulence. If an invading organism has a serious potential to cause grave damage, then by the time specific antibodies are produced, significant morbidity, or perhaps mortality, may be experienced by the host. It would thus be very advantageous to the host if active immunity could be acquired before the onslaught of the particular pathogen. This is where vaccines can become useful as disease prevention measures.

Although the terms *vaccination* and *immunization* are often used interchangeably, the word immunization is a broader term. The etymology of the word "vaccine" derives from the Latin word "vacca," meaning cow. More than 200 years ago Edward Jenner inoculated a young man from England with material from a dairymaid who had cowpox. Cowpox is an infection indigenous to cows and other mammals in Europe that can be acquired by humans. It is a disease with very low morbidity and mortality in humans. Jenner found that cowpox deliberately introduced into a human makes the person immune to smallpox. In the true sense of the word, vaccination is an immunization for smallpox [5–7]. The term *immunization* is less specific.

Immunization involves the use of any pathogen-associated substance or immunobiologic as a prevention of disease caused by a specific antigen [8]. A pathogenic organism, or antigenic fragment, could be used as an immunobiologic to confer immunity to a host against a disease caused by that pathogen.

Glossary of terms:

Immunobiologic
Antigenic substance or antibody containing preparation used to induce immunity and prevent infectious diseases.
Active immunization
Use of an antigenic substance to induce immunity by stimulating an immune response.
Vaccine: A suspension of live (usually attenuated) or inactivated micro-organisms, or fractions thereof.
Toxoid: A modified (nontoxic) bacterial toxin that is capable of stimulating antitoxin formation.
Passive immunization
Use of an antibody containing preparation to enhance or restore immunity.
Immune globulin (IG): A sterile solution containing antibodies from human blood.
Antitoxin: A solution of antibodies derived from the serum of animals immunized with specific antigens.
Vaccine
Monovalent: A vaccine consisting of a single strain or type of organism.
Trivalent: A vaccine consisting of three types of strains of a single organism (influenza vaccine), or three different organisms (DPT vaccine).
Polyvalent: Multiple strains or types of organisms in the vaccine (23-valent pneumococcal vaccine).

Active immunization is acquired by the host when a vaccine or toxoid initiates humoral or cell mediated immunity of the host relative to a specific pathogen [6]. Subsequent to this event, the host, via immune system memory, will be able to initiate a more potent and rapid response to the actual infectious agent should contact occur. Passive immunization involves the administration of antibodies derived from sources other than the host (exogenously). The source of these antibodies could be from immunized animals or other humans. Passive immunization may occur after a known exposure to a pathogen [6].

Vaccines are composed of live or inactivated micro-organisms, fragments of pathogens, or are created synthetically. The live pathogens are usually attenuated or weakened. In this state they cannot produce significant disease in immune-competent individuals. Vaccines also contain fragments of the pathogen or an altered form of the pathogen so that they cannot produce infection [1,9]. The fragments or altered forms contain enough molecular structural information to mark it for memory in the immune system [1]. Frequently, attenuated solutions are made by repeatedly passing the pathologic agent though tissue culture or animal hosts until virulence is decreased. Important morphological characteristics are retained to provide information to induce lymphocyte memory and confer immunity [4].

Some vaccine agents are made synthetically through the use of recombinant DNA technology. This involves reconstructing antigen molecular morphology to create lymphocyte memory to a pathogen. Thus an extra degree of safety is obtained [5].

Immunizations indicated for oral health personnel

Disease prevention is often viewed as the key to public health. It is more advantageous to prevent a disease than it is to treat it. Vaccines are responsible for the control and elimination of many diseases once endemic throughout North America including measles, diptheria, pertussis, polio, rubella, mumps, smallpox, tetanus and influenza [1,4,9–11].

For healthy adults living in the continental United States and Canada, some vaccines are recommended regardless of a person's occupation [9,12]. Exclusive of special situations or travel, it is recommended that all healthy adults in the Unites States of America should have received vaccinations for measles, mumps, rubella (MMR) and pneumococcal disease. For adults born after 1956, at least one dose of MMR vaccine is recommended. Some individuals will need two doses [9,12–15].

Tetanus can have serious clinical outcomes. Ninety-five percent of tetanus (lockjaw) cases occur in adults, and there is a 40% mortality rate [13]. A primary series of tetanus-diphtheria (Td) injections should be given to any unvaccinated adults who have not been vaccinated with a booster every 10 years. Varicella vaccine is recommended for healthy adults. More detail on the vaccines themselves, their indications, risks, benefits, and contraindications is provided later.

Measles is a highly contagious disease caused by paramyxovirus, genus Morbillivirus, which produces systemic infection [16]. The skin and respiratory tract are primarily involved. The infected individual becomes sick with fever and skin lesions. The disease is rarely fatal, but adults can have significant morbidity, including meningitis [1,14]. German measles (rubella) is contagious and is classified as a togavirus. Although the disease often has a mild clinical course, it poses a danger to pregnant women because of possible fetal problems associated with the disease [1,7,14]. Mumps is a common infectious disease cause by a paramyxovius. After an incubation period of 12 to 14 days, salivary gland involvement occurs particularly in the parotid glands. It is not as communicable as measles or rubella. Morbidity is usually mild and short lived in children. However, in adults, more serious complications may arise, such as ovarian or testicular involvement. MMR vaccines have been shown by clinical studies to have a favorable risk-benefit ratio. It has also been shown that it is more fiscally sound to prevent rather than treat these diseases [14,17].

The morbidity and mortality associated with hepatitis B virus (HBV) is a major health problem in the United States, with more than 1 million people chronically infected [18]. Chronically infected individuals are at

increased risk for hepatitis, cirrhosis, and hepatocellular carcinoma [19]. Chronic HBV infection is defined as persistence of hepatitis B surface antigen (HbsAg) for longer than 6 months. This form of chronicity exists in 5% to 10% of exposed individuals [20].

Hepatitis B vaccine is not routinely recommended for all adults [1,13]. Oral health care providers, healthy adult Americans that work in mortuaries, sexually active people with multiple partners, and people that have routine contact with any person in the nonoccupational setting that are known HBsAg carriers should receive the vaccine. People with increased potential to develop disease, such as individuals on hemodialysis and IV drug users, should be vaccinated for HBV as well [1,9,13].

Residents of nursing homes or long-term care facilities are at risk for influenza. People over the age of 65 and health care workers should receive influenza vaccinations [12]. Individuals with compromised health should be vaccinated for influenza regardless of age. Examples include patients with chronic heart or lung disease, uncontrolled diabetes mellitus, asthma, kidney failure, or compromised immune systems [21,22]. The vaccine for pneumococcal (primarily pneumonia) infection should also be provided for people who are at high risk for contracting influenza [1].

Hepatitis A is a disease caused by hepatitis A virus (HAV). This virus is not primarily bloodborne, but is transmitted by the fecal-oral route. Hepatitis A has a high degree of morbidity but a low mortality rate. It is often asymptomatic in young children but is more serious in adults, causing jaundice, severe abdominal pain, and diarrhea [22,23]. Every year about 100 Americans die of acute hepatitis A. For people over 50 years old, the mortality rate is 1.8% [24]. Hepatitis A infection is self-limited, and recovery from the disease is often complete [19]. Chronic liver disease is not associated with hepatitis A, as it is with hepatitis B, C, or D. There is also no life-long carrier state as in hepatitis B, C, or D [1]. Hepatitis A vaccine is indicated for those individuals who travel to endemic third world countries, have liver disease, are IV drug users, or are male homosexuals. Hepatitis A vaccine is also indicated for dental health care personnel who work with residents of mental facilities and penal institutions [12,25,26].

Implications for oral health care workers

The Advisory Committee on Immunization Practices (ACIP) defines health care workers (HCW) as members of the professions of medicine, nursing, dentistry, biomedical laboratory technicians, and emergency medical personnel [15]. Dentists often have contact with patients in confined spaces where aerosols are generated via handpieces, ultrasonic scalers; where sharp instruments are used, bloodborne pathogens become a danger, which puts dental health care workers at risk for bloodborne infection. Although

there is a chance that dentists can infect their patients, dentists are at a greater risk for contracting diseases from their patients than patients are from their dentists [27]. Maintenance of immunity is an important part of disease prevention and infection control in dental offices and hospital-based oral health programs. Use of vaccines safeguards the health of workers in various types of oral health care delivery settings. Based on documented nosocomial transmission, oral health care workers are at considerable risk for hepatitis B, influenza, measles, mumps, rubella, and varicella [28–30]. These are all vaccine preventable (Table 2, Box 1) [9,15,31].

Diseases that have a predilection for transmission in the oral health care setting can be grouped into two categories:

1. Those for which active immunization is *strongly recommended* because of the special risks involved in delivery of dental care;
2. Those for which immunoprophylaxis *may be needed* because of *special* circumstances; these settings may be hospital-based clinics, other special care clinics, or field-based operations in areas that may have specific endemic diseases among patients.

According to the ACIP, immunoprophylaxis for all oral health professionals is strongly recommended for hepatitis B, influenza, measles, mumps, rubella, and varicella [15]. Adult groups often targeted for immunization against influenza often overlap with individuals who should be vaccinated against pneumococcal disease (Fig. 1). Oral health care workers who are uncertain about their immunization history should consider the pneumoccal polysaccharide vaccine [32]. There are other diseases for which immunization of oral health care workers may or may not be indicated based on special health care delivery situations [15].

One of the diseases to be considered in the "may or may not need immunization" category, based on special circumstances, is tuberculosis (TB). Geographic areas in North America, such as California, New York, Florida, and Texas, have an elevated prevalence of tuberculosis patients seeking care in medical and dental facilities, thus putting the health care providers at increased risk of contracting TB [15]. Oral health care workers practicing in inner city locations are at greater risk [33].

Of particular concern are multi-drug resistant strains of *M tuberculosis*. Nosocomial outbreaks of TB have occurred [34,35]. Although the primary measures to prevent TB transmission in these settings are still vigilant use of standard precautions and the use of ultra small particle filter masks, immunization with Bacillus Calmette and Guerin (BCG) vaccine is still an important consideration.

Oral health care workers are generally not considered to be at occupational risk for hepatitis A [19]. Most transmission of hepatitis A to health care workers in general involves exposure to fecal material from individuals receiving care [15,19,33]. This may be of significance to dentists who work in nursing homes or hospitals as their primary setting. Oral health

Table 2
Recommended vaccines for oral healthcare workers

Generic name	Primary and booster schedules	Major precautions and contraindications
Hepatitis B recombinant	Two doses IM 4 weeks apart, third dose five months after second.	Previous anaphylactic reaction to common baker's yeast Note: Pregnancy is not a contraindication if the woman is otherwise eligible.
Rubella live virus vaccine	One dose SC, no booster	Pregnancy; immunocompromised condition; history of anaphylaxis after taking neomycin
Measles live virus vaccine	One dose SC, no routine boosters	Pregnancy; immunocompromsied condition; history of anaphylactic reaction after eating eggs or taking neomycin
Mumps live virus vaccine	One dose SC, no booster	Pregnancy; immunocompromised condition; history of anaphylactic reaction after eating eggs or taking neomycin
Influenza vaccine (inactivated whole-virus and split-virus vaccine)	Annual vaccination with current vaccine, either whole or split-virus	Pregnancy; history of anaphylactic reaction after eating eggs
Tetanus-diphtheria toxoid	Two doses IM 4 weeks apart, third dose 6 to 12 months after second dose, booster every ten years	Pregnancy; history of neurological reaction or immediate hypersensitivity reaction after a previous dose
Varicella live virus vaccine	One dose SC for persons ages 12 months to 12 years, second dose 4 to 8 weeks after first for those ages 13 and up	Pregnancy; allergies to neomycin or gelatin; history of anaphylaxis to previous dose; immunocompromised condition; corticocosteriod use; receipt of blood products in previous 5 months

Abbreviations: IM, intramuscular; SC, subcutaneous.
Adapted from Vaccinations update. OSAP Monthly focus 1997;12:1–6; with permission.

care providers should be immunized for hepatitis A based on the criteria addressed previously in this chapter for adults.

Meningococcal disease is another disorder characterized by the ACIP as possibly indicated for immunization of health care workers in special circumstances. Transmission of *Neisseria meningitidis* in the health care delivery setting is rare. Dentists closely examining the oropharynx of patients, or in close proximity to patients with *N meningitidis* infection, are at risk for contracting the disease [36]. Only oral health care workers who work in hospital settings where the above contacts may occur or where there has been an unusual clustering of meningococcal disease should be immunized with pneumococcal vaccine.

Box 1. Diseases for which vaccines are available in the United States

Anthrax	Hepatitis A	Plague	Smallpox
Chickenpox (varicella)	Hepatitis B	Pneumococcal pneumonia	Tetanus
Cholera	Influenza	Polio	Typhoid fever
Diphtheria	Measles	Rabies	Whooping cough
Heamophilus influenzae type b infections	Mumps	Rubella	Yellow fever

Adapted from Vaccinations update. OSAP Monthly Focus 1997;12:1–6; with permission.

Characteristics of specific vaccines for oral health care workers

MMR vaccine

Measles transmission in the health care setting has been documented in private practices and in hospitals. It is the most contagious of human infections and worldwide causes 30% of all deaths due to vaccine-preventable diseases [4]. The risk for measles infection in health care workers is thirteenfold greater than in the general population [15]. All health care workers who come in contact with patients should be immunized against measles [37]. As mentioned earlier, at least one vaccination for MMR is needed for adults born after 1956. In some instances, a second vaccination is necessary [9]. Members of this age group that are attending college, health care workers, or people who are otherwise spending time in environments that would put them at risk for endemic exposure to measles should have documentation of having received two doses of MMR near or after their first birthday or show evidence of immunity [1].

Most adults born before 1957 have acquired natural immunity from previous exposure to measles in their living environment [9]. Serologic studies have revealed, however, that up to 9.3% of hospital workers born before 1957 did not have immunity to measles [37]. Furthermore, between 1985 and 1989, 29% of all measles cases among health care workers were among those born before 1957 [37]. Health care centers and owners of private practices should strongly consider protocols requiring one dose for older professionals and staff who do not have proof of immunity to the disease. People born after 1957 should be considered immune if they can produce documentation of:

- Physician-diagnosed measles
- Laboratory evidence of immunity
- Two doses of live measles vaccine on or after age 1, separated by at least 1 month [37].

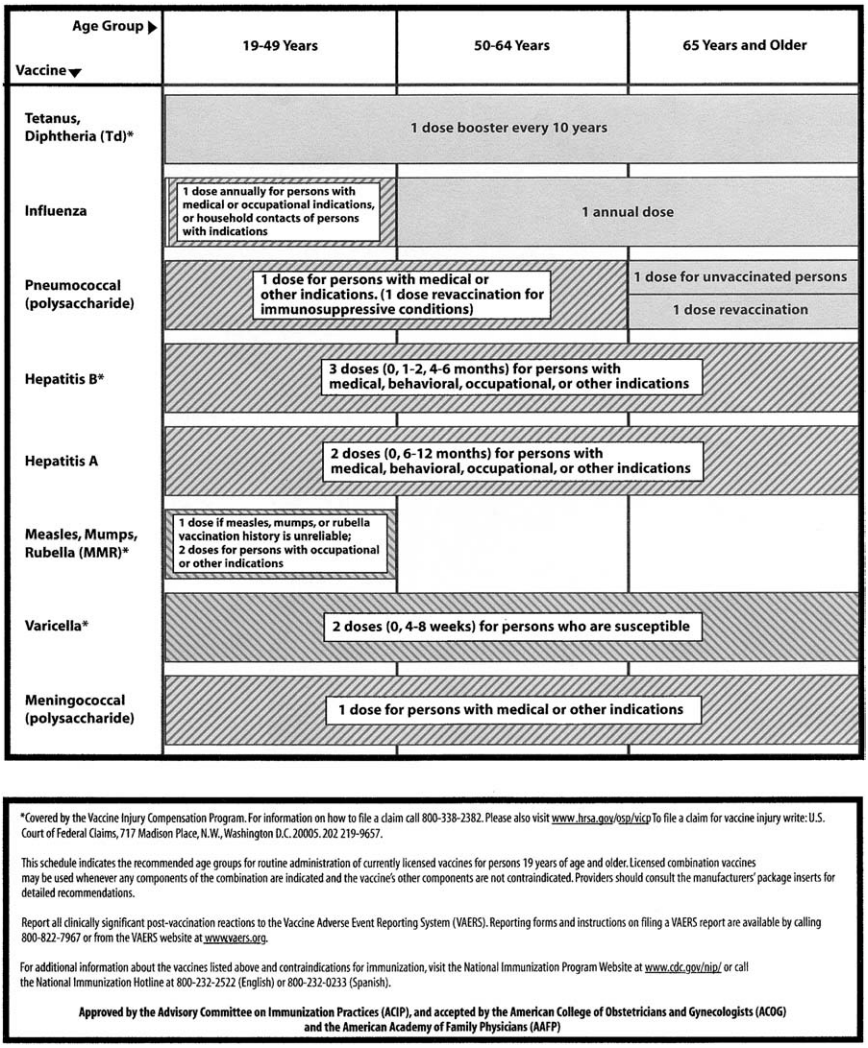

Fig. 1. Recommended adult immunization schedule, United States, 2002–2003. Solid = For all persons in this group; Right slant = Catch-up on childhood vaccinations; Left slant = For persons with medical/exposure indications.

Mumps often has a mild clinical course in children but may have more significant morbidity in adults. In recent times a large percentage of mumps has been reported among college students and in the workplace [15]. As with measles, people born before 1957 are considered to have been infected naturally and are considered immune. People born after 1957 can be considered immune if and only if they have documentation of:

- Physician-diagnosed mumps

- Laboratory evidence of immunity
- Immunization with live mumps vaccine on or after their first birthday [37].

Every health care worker that comes in contact with patients should be immune to rubella [38]. Rubella usually has a very mild clinical course but may present problems for the pregnant health care worker insofar as the developing fetus is concerned. Birth before 1957 is generally considered an indication that a health care worker is immune to rubella. However, oral health care workers who lack historical or laboratory evidence of rubella should consider the MMR vaccine [8].

People should be considered susceptible to rubella unless documented immunization before age 1 or laboratory evidence indicates otherwise [37]. If the population was not vaccinated for MMR, the cost of treating the estimated numbers of cases along with expected dollar loss of productivity would be 14 times greater than the cost of the vaccination programs for MMR [14], producing a very favorable cost/benefit versus risk ratio in favor of immunization.

Immunization for any or all of the above-mentioned diseases (measles, mumps, and rubella) is usually given as the trivalent vaccine known as MMR [15]. No evidence suggests that administration of MMR vaccine causes adverse reactions in people who are already immune to measles, mumps, or rubella from previous vaccination or disease [9]. Although individual vaccines can be administered (monovalent or bivalent), MMR trivalent vaccine is the vaccine of choice if recipients have a susceptibility to measles, rubella, and mumps [15]. MMR is a live vaccine and as such should not be given to pregnant woman or immunocompromised individuals [9,39,40]. Women receiving the monovalent component vaccines containing measles or mumps should be counseled to avoid getting pregnant for 30 days after administration or for 3 months after receiving rubella or MMR vaccines [15].

Some individuals may experience allergic reactions to the MMR vaccine. The allergic response can be local or systemic and runs the spectrum from urticaria and hives to true anaphylaxis [8]. Components of MMR vaccine are extracted from chicken embryo cell cultures, and for this reason people allergic to chicken eggs or egg products should not receive the vaccine [40].

Rubella vaccine can be grown in human tissue-based substrates. These cultured derivatives can safely be used for people sensitive to egg proteins [9]. Other possible side effects of MMR vaccination may include fever 5 to 12 days after receiving the vaccine and a transient rash appearing in 5% of individuals. Joint pain of short duration is observed in 25% to 50% of individuals receiving the rubella component of the vaccine [40].

Varicella vaccine

Varicella zoster virus (VZV) is ubiquitous in the United States with 90% of the population having contracted chickenpox by the age of 15 [40]. It is spread via airborne vector from secretions of the respiratory tract of infected

individuals or through contact with fluid from the vesicles or mucus membranes. Solid objects also are considered to be potential vectors. Varicella infections are usually mild with a high morbidity/mortality associated with primary viral pneumonia in adults and encephalitis in children. Most cases of varicella-mediated illness include sudden onset of low-grade fever and maculopapular skin eruptions that become vesicles [40]. Testing for antibodies to the varicella virus is recommended for all health care workers. A positive antibody test denotes immunity [41].

The varicella vaccine contains live attenuated VZV. It is indicated for children over the age of 1 through adulthood. The vaccine provides 70% to 90% protection against varicella-produced disease. In addition it gives 95% protection against the risk of high morbidity should someone already vaccinated become infected with the varicella virus [40]. The varicella vaccine contains live attenuated particles that induce both humoral and cell-mediated immunity. The manufacturer recommends that adults who have demonstrated immunity should receive two doses of 0.5 mL of the varicella vaccine 4 to 8 weeks apart. Nosocomial transmission of varicella-mediated disease represents a significant vector for disease in health care workers as well as their high-risk patients [42]. Dentists who are not immunized and work in very close proximity to immunocompromised patients not only have their own health to consider but can transmit disease to patients who could potentially experience severe morbidity and possible mortality. Poor responders to the initial vaccine should have a second dose [42].

Adverse effects associated with the varicella vaccine include mild injection site pain and localized rash. Risk of transmission of the viral component to household contacts is rare. Administration of the vaccine is contraindicated for people allergic to neomycin and gelatin (components of the vaccine). As the vaccine contains live, albeit attenuated virus, it is contraindicated in immunocompromised individuals. Pregnant women should postpone the vaccine until after delivery and should not become pregnant until 1 month after receiving the vaccine [43]. People who have received transfusions or other blood products should postpone administration of varicella vaccine for 5 months.

Tetanus vaccine

Tetanus toxoid was first made in 1924 and was used in the armed services during World War II. It is recommended that children under 7 should receive three properly spaced doses. Four weeks after the first dose, the second is administered and the third dose is administered 6 to 12 months after the second dose. For children and adults older than 7, four properly spaced doses should be administered [16].

Because levels of antitoxins can fall, a booster is recommended every 10 years; however, if there is a substantial injury that is open to infection, and

over 5 years have lapsed since the last booster was administered, normally another booster is given at that time [16].

There are some adverse side effects that have been seen from the tetanus vaccine including local adverse events, exaggerated local reaction, and severe systemic reactions. Local adverse events include erythema, induration, and pain at the injection sight. These manifestations are normally limited to the site and do not require any treatment. Fever is not normally observed, but localized abscess formation at the site has been reported. Exaggerated local reactions can be seen 2 to 8 hours after receiving a tetanus vaccine. Swelling normally occurs from shoulder to elbow and is a sign that the person may have high antitoxin levels. Normally a person in this situation would not require an emergency dose after 5 years if they have an injury. Severe systemic reactions include urticaria, anaphylaxis, or neurologic complications. The vaccine should not be administered if the person has had reactions with previous administrations. Examples of such reactions include loss of consciousness or acute respiratory distress. There are two cases when the vaccine should be deferred. The first is if the person is suspected to have an allergy to the vaccine. In that case they should be tested for the allergy before receiving it. The second case for deferment is if they have a severe or acute illness [16].

Influenza vaccine

Individual adults in the general population under certain conditions should be vaccinated against influenza regardless of health care occupational status. Influenza vaccination is strongly recommended for all health care providers [15,40,44]. The ACIP has recommended to prioritize vaccination efforts for health care workers for the 2002–03 season. Influenza is a potentially dangerous viral infection and is spread through the nose and throat of infected individuals. It can cause fever, cough, sore throat, and headache. Influenza causes thousands of deaths each year [22]. Influenza viruses often undergo antigenic morphologic changes. Each year the vaccine for influenza contains three viral strains. These represent influenza viruses that are most likely to be indigenous to a particular area of the country in the upcoming season. The three strains are usually two type A and one type B [25]. Influenza A viruses are classified into subtypes based on surface antigens hemagglutinin (H) and neuraminidase (N). Combining these two, there are now five strains recognized among influenza A viruses [25]. The virus strains in the vaccine may not vary significantly, but immunity declines in the year after vaccination [25]. It is important for reasons of viral variability and declining immunity that the health care worker be immunized each year during October or November. Every year 25% of health care workers contract influenza during the winter months [45].

There is significant morbidity associated with influenza; however, many affected health care workers will often report to work and can transmit the

virus to others even if they are asymptomatic [45]. It has been determined that in healthy adults immunization reduces absenteeism caused by respiratory infections secondary to influenza [17,46]. Data relative to this type of efficacy in health care workers has been less certain. A randomized placebo-controlled double-blind study on the efficacy of influenza immunization on absenteeism of health care workers in 1999 concluded that influenza vaccination reduced absenteeism related to respiratory infections by 28%. This study recommended routine annual influenza immunizations for all health care workers [46]. Cost effectiveness for administration of influenza vaccine has been determined to be favorable [47].

Adverse effects associated with influenza vaccine include pain or erythema at the injection site, fever, malaise, and myalgia [25]. The influenza vaccine is a completely deactivated virus, so that there is no chance of contracting disease from the vaccination [25]. Contraindications include people with allergic reactions to eggs and a history of Guillain-Barre syndrome [22]. Despite the relative safety of influenza vaccine, it has been demonstrated that many health care workers fail to receive the vaccine each year [48]. Strategies projected to increase the percentage of oral health care workers vaccinated for influenza include emphasizing safety and efficacy and providing convenient and low cost vaccines.

Hepatitis B vaccine

Immunization with hepatitis B vaccine is the most effective means of preventing HBV infection and its sequelae [18]. According to the ACIP, any health care worker that performs procedures involving contact with blood, blood-contaminated body fluids, saliva, or sharp instruments should be vaccinated against HBV [15]. There are two hepatitis B vaccines available in the United States and both are recombinant preparations. The use of recombinant technology enables the manufacturing of vaccine without viable virus particles or components of blood from other individuals. This should allay any fears that oral health care workers may have concerning the contraction of HBV or HIV from the vaccine.

Serologic testing is not necessary before use of the vaccine [15]. It may be used to screen for immunity due to prior infection. If an individual's immunity to HBV is questionable and an incident leading to possible infection with HBV occurs, then hepatitis B immune globulin (HBIG) should immediately be administered [15].

Monetary analysis has demonstrated that using the CDC guidelines for administrating postexposure HBIG to health care workers is always more cost effective than routinely performing serologic testing for anti-HbsAg titer after immunization [49]. Routine postimmunization blood tests for adequate antibody response to hepatitis B virus is recommended for oral health care workers who come in contact with blood [50]. Testing for circulating antibody also is recommended for clinicians older than age 30 at

the time of vaccination or with other conditions that may compromise the immune system's ability to develop an antibody response. Increasing age in health care workers has been shown to negatively affect their seroconversion rates and subsequent immunity to hepatitis B. The differential can be as large as 42.0% seroconversion for those over 50 years of age compared with 83.3% for those significantly under 50 years of age. Other factors that modify seroconversion rates include gender and the presence of chronic illness [51].

Immunization against hepatitis B should be completed during the professional training of the oral health care worker. The oral health care professional or student is considered to be the most vulnerable to hepatitis B infection at this time [52]. Immunizing health care workers prevents nosocomial transmission from health care worker to patient and from patient to health care worker [52]. All oral health care workers should be offered the opportunity to receive the vaccine at the start of their employment if they have not been immunized up to that time. The Federal Standard under the Occupational Safety and Health Act requires that hepatitis B vaccine should be made available at the employer's expense to all health care workers who work with blood or other infective materials [53].

Immunization against HBV requires three doses. The second dose is administered 1 month after the initial dose and the third dose is at 6 months. The first two doses work as priming agents, and the extended interval between the second and third doses enhances the power of the immune response [26]. The third dose embeds maximum protection and acts as a booster dose [18].

Continual protection against a specific antigen depends on immunologic memory or anamnestic response. For hepatitis B vaccine this memory seems to last at least 15 years in individuals who do not have immunocompromising conditions [54]. The absence of detectable circulating anti-HbsAg does not indicate a loss of protection [26]. Booster shots are not routinely recommended for oral health care workers unless the person is at increased risk because of their work environment [15]. Antibody titers should be tested between 30 to 60 days after last dose. Persons with compromised immune systems do not respond well to HBV vaccine [26]. For immunocompromised health care workers, periodic testing for anti-HbsAg should be performed and a booster injection given if the titer falls below 10 mlU/mL [54].

Vaccinated persons with a negative antibody response can receive another dose of the vaccine with an estimated 20% chance of success or another series of three doses with an estimated 30% to 50% response rate [51]. If individuals do not respond after six doses of vaccine, they are not likely to respond to further vaccinations. People who are not responsive to the primary vaccination series and who do not respond to the second series should be considered susceptible to hepatitis B and counseled accordingly.

The administration of hepatitis B vaccine can be juxtaposed with other vaccines without regard for time sequence [18]. It is recommended that

different syringes and anatomic sites be used if the vaccine is used concomitantly with other vaccines. When the hepatitis vaccine is administered properly and in recommended sequence, it is effective in producing seroconversion and protection in more than 90% of healthy young recipients [51]. Approximately 5% of healthy young adults do not obtain immunity from the vaccine after the primary series [26]. People who initially respond to the vaccine and build adequate antibody titers and later experience decreased levels of antibody appear to be protected [15].

Adverse effects associated with the hepatitis B vaccine include soreness at the injection site, low-grade fever, myalgias, and malaise. There do not seem to be any severe adverse reactions associated with the vaccine. There are no contraindications to the hepatitis B vaccine other than previously demonstrated hypersensitivity to the vaccine or any of its components. Allergy to thimerosal is a true contraindication to hepatitis B vaccine [55]. It has been hypothesized that hepatitis B vaccine may cause certain demyleinating neurologic disorders such as multiple sclerosis and Guillain-Barre syndrome. Presently, there is no epidemiologic evidence to support such a causal relationship [55]. Hepatitis B vaccines are safe and reliable methods of controlling the spread of HBV.

Hepatitis A vaccine

The clinical features of hepatitis A disease, as well as the indications for hepatitis A vaccine, have been discussed earlier. Human HAV can be cultivated in cell culture, and this feature of HAV has enabled development of live-attenuated and inactivated vaccines [26]. Two products have been developed as inactivated hepatitis A vaccines: HAVRIX (GlaxoSmithKline, Philadelphia, Pennsylvania) and VAQTA (Merck & Company, Whitehouse Station, New Jersey) [56].

The HAV vaccines are very effective in the prevention of clinical disease, ranging from 94% to 100% [56]. The immune response to the vaccines is potent, and postvaccination serologic testing is not indicated [19]. Antibody decay equations extrapolate that protection conferred by HAV vaccines may last up to 20 years [56]. The vaccine should be given from 2 to 4 weeks before travel or other situations requiring the immunity to be in place.

Vaccination schedules for the HAV vaccines are as follows:

- HAVRIX: indicated for people 18 years or older, two doses, the second given 6 to 12 months after the first;
- VAQTA: indicated for people 17 years or older, two doses, the second given 6 months after the first [15].

Recently the FDA approved a new combined HAV-HBV vaccine called Twinrix (GlaxoSmithKline Biologicals). It is indicated for vaccination of people 18 years of age or older who have an indication for both hepatitis A and hepatitis B vaccination [57].

Adverse effects associated with HAV vaccine include rare allergic reactions, soreness at the injection site, headache, anorexia, and malaise [58]. As with all vaccine strategies, the risk of harmful associated effects is far less than the potential harm caused by the disease. The only contraindication for receiving the HAV vaccine is previous sensitivity to the vaccine or any of its components [58].

Tuberculosis vaccine

The indications for immunization against TB relative to oral health care workers and the general population have been considered earlier. In the United States, the use of BCG vaccine is a TB control strategy that is recommended only for individuals who meet established criteria. Consequently, it is rarely indicated because the overall risk of acquiring infection from *Mycobacterium tuberculosis* is very low for the general population [59]. According to the CDC, health care workers in general are not routinely recommended to receive the BCG vaccine. Immunization is indicated only when *all* of the following criteria are met:

- The patient pool for a particular oral health care worker has a high percentage of active TB-infected individuals who are resistant to both isoniazid and rifampin; and
- Transmission of the infection to the health care worker is likely; and
- TB infection control measures have been attempted and proved to be unsuccessful [15].

Adverse effects associated with BCG vaccine include serious complications possible in immunocompromised individuals, especially those that may be infected with HIV. The oral health care worker should understand that the vaccine may interfere with the diagnosis of newly acquired TB and that the data involving the vaccine's effectiveness in preventing multiple drug resistant TB are equivocal [15]. Thus the risk-benefit analysis relative to administration of BCG vaccine to an oral health care provider should come under close scrutiny. Only dental health care workers who regularly come in contact with patients that have active cases of TB should receive the vaccine.

Contraindications, precautions, and adverse reactions

Although modern immunobiologics are both safe and effective, adverse reactions are associated with all vaccines and vary as to the type of vaccine and the idiosyncrasies of the individual recipient. Given these variables, adverse reactions remain relatively constant across a representative group of immunobiologics. True contraindications and precautions are often temporary, and the vaccine may be indicated and advisable at a later time when and if the individual's circumstances change [9].

A true contraindication is a condition in the proposed recipient that increases the probability for a potentially dangerous reaction. The only definite contraindication across the entire spectrum of vaccines is a history of allergic reaction to a previous exposure to the particular vaccine or one of its components. A precaution is a condition in a recipient that may tend to decrease the chances of obtaining immunity after administration of the vaccine [9]. Again, a precaution may be temporary and may involve something that may be transient such as a temporarily reduced state of immunocompetence. Cancer chemotherapy or immunosupressant drugs to prevent graft-host rejection after reception of transplanted organs could represent such conditions [8].

Premarketing safety for all drugs, including vaccines, is determined and sanctioned by the Food and Drug Administration (FDA). Trials involve several thousand patients but once the drug is certified and on the market, millions of people receive the drug and a more comprehensive profile of the potential adverse effects is identified. Adverse effects to vaccine administration in general are monitored by the Vaccine Adverse Event Reporting System (VAERS). VAERS is in turn monitored by the FDA and the CDC [8,60]. Adverse events reported by VAERS do not necessarily prove cause and effect. Other environmental or individual clinical idiosyncrasies may contribute to the reported incident that would be at the association or correlation level rather than causality [60].

Vaccine considerations for the immunocompromised oral health care worker

Advances in medical technology and treatment have enabled more people with debilitating diseases and weakened immune systems to be ambulatory and functional in everyday life. This situation applies to health care workers as well. The health care workforce accounts for approximately 3% of the total population [5]. Most of the immune conditions confronting oral health care workers are secondary or acquired. Serious immunosuppression can be caused by HIV infection, leukemia, other malignancies, or therapy with antimetabolites, radiation, or administration of corticosteroids (Fig. 2) [9].

Vaccines that use killed virus components do not represent a danger to immunocompromised oral health care workers. The same vaccine regimens normally used for these vaccines can be administered to persons with weakened immune systems [8,9]. Additional vaccines are actually recommended for these individuals. Polysaccharide vaccines such as *Haemophilus influenzae* type b vaccine as well as pneumococcal and meningococcal vaccine are often used when dealing with patients who have compromised immune systems [15].

Immunocompromised health care workers should not receive live vaccines except in rare circumstances [9]. Individuals receiving chemotherapy or radiation treatment should not be immunized with any type of

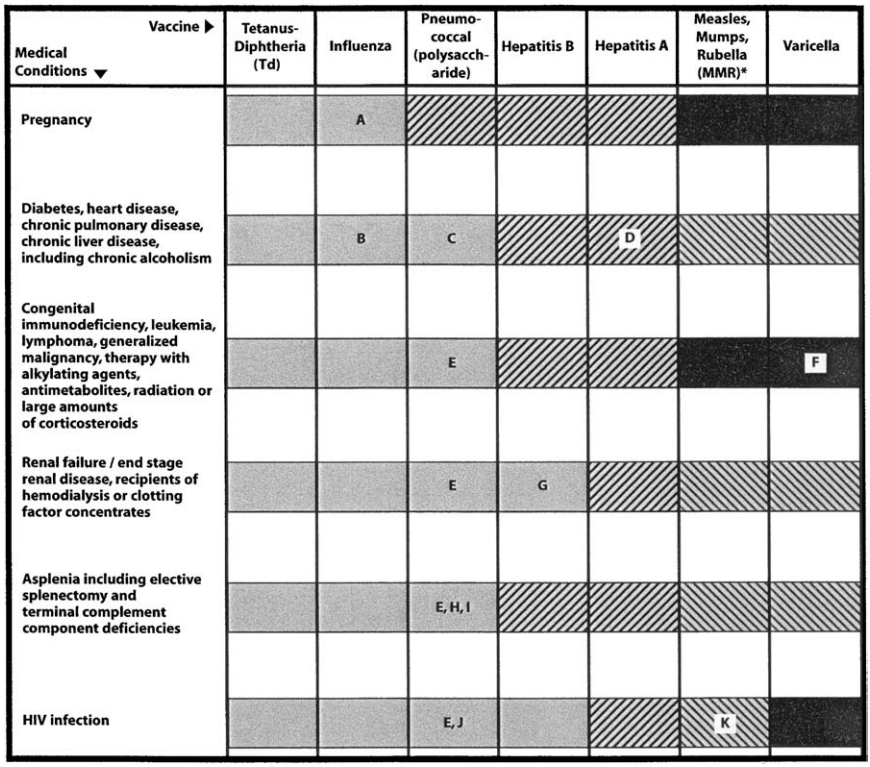

Fig. 2. Recommended immunizations for adults with medical conditions, United States, 2002–2003. Light gray = For all persons in this group; Right slant = Catch-up on childhood vaccinations; Left slant = For persons with medical/exposure indications; Dark gray = Contraindicated. A, If pregnancy is at 2nd or 3rd trimester during influenza season; B, Although chronic liver disease and alcoholism are not indicator conditions for influenza vaccination, give 1 dose annually if the patient is $\geq$50 years, has other indications for influenza vaccine, or if the patient requests vaccination; C, Asthma is an indicator condition for influenza but not for pneumococcal vaccination; D, For all persons with chronic liver disease; E, Revaccinate once after 5 years or more have elapsed since initial vaccination; F, Persons with impaired humoral but not cellular immunity may be vaccinated, MMWR 1999;48(RR-06):1–5; G, Hemodialysis patients: use special formulation of vaccine (40ug/mL) or two 1.0 mL 20 ug doses given at one site. Vaccinate early in the course of renal disease. Assess antibody titers to help B surface antigen (anti-HBs) levels annually. Administer additional doses if anti-HBs levels decline to $<$10 milliinternational units (mIU)/mL; H, Also administer meningococcal vaccine; I, Elective spelnectomy: vaccinate at least 2 weeks before surgery; J, Vaccinate as close to diagnosis as possible when CD4 cell counts are highest; K, Withhold MMR or other measles containing vaccines from HIV-infected persons with evidence of severe immunosuppression, MMWR 1996;45:603–6, MMWR 1992;41(RR-17):1–19.

vaccine during these treatment periods. Immunization can be considered 3 months after discontinuation of therapy. This is because not only will the antibody response be inadequate, but serious complications can result for the recipient [8].

Corticosteroid therapy requires consideration relative to immunization protocols. It is difficult to determine the amount of systemically absorbed steroid needed to significantly suppress the immune system. According to the CDC, short-term (ie, <2 weeks) corticosteroid therapy is usually not a contraindication to administering live-virus vaccines. The CDC concluded that the immunosuppressant effects of steroid therapies vary. A prednisone dose equivalent to either 2 mg/kg of body weight or up to a maximum of 20 mg/day of prednisone may be enough to question the safety of administering live virus [9]. Live virus vaccines should not be given for at least 3 months after steroid therapy that exceeds 2 weeks in duration.

The CDC has outlined specific recommendations for HIV-infected health care professionals relative to immunization protocols:

- MMR vaccine is recommended for all HIV-infected individuals who are asymptomatic and who show little evidence of immunosuppression.
- Individuals who are HIV infected and are symptomatic, but do not have severe immunosuppression should also be considered candidates for vaccination.
- Additionally the CDC concludes that measles vaccine is contraindicated for HIV infected persons with severe immunosuppression.

Risks versus benefits of vaccines for individual patients are part of the clinical decision-making process as in all matters of medicine. Determination of the immune competence of an oral health care worker relative to their ability to be a recipient of immunizations ultimately must be made by their physician [15].

Future of vaccinations for oral health care workers

Delta hepatitis is a serious and often acute viral liver disease. Hepatitis Delta virus (HDV) requires the presence and activity of HBV to survive and is preventable with the HBV vaccines [8,9]. Hepatitis C is a disease that has a growing presence in the United States and is responsible for considerable morbidity and mortality. The chronic nature of the disease and the ability of the virus to escape immune surveillance make it an insidious threat to oral health care workers. Although the occupational risk in dentistry does not seem to be significantly higher than in the general population, a vaccine would be a very welcome addition to our disease prevention armamentarium [61]. There is some evidence to indicate that occupational transmission of HCV does occur in the health care setting [61].

Presently, there is no vaccine for hepatitis C. The HCV genome exhibits significant heterogeneity resulting from mutations occurring during replication. There are six genetically distinct HCV groups or genotypes [62]. Within these genotypes there are more than 50 subtypes [63]. This makes the development of a vaccine very complex. A further complication

in the development of a HCV vaccine is that these mutations develop within an individual during the course of the infection [63].

Another complication in the development of HCV vaccine is the inability to produce active tissue cultures. This ability to form tissue cultures has been important to the process of successfully developing other vaccines and is not a viable modality for HCV [63].

The most promising avenue of pursuit in the development of a hepatitis C vaccine resides in the technology of synthetic molecular biology using DNA priming and recombinant virus protein synthesis. Another problem with hepatitis C prevention is the lack of an effective postexposure immune globulin [61]. The prevention of HCV occupational transmission for the present time thus lies within the use of standard precautions in the oral health care setting.

When HIV was discovered in 1983, the Secretary of the United States Department of Health and Human Services predicted that a vaccine would be available within 2 years [64]. Several AIDS vaccines are in clinical trials. There are 11 primary subtypes or clades, of HIV. Research is now being directed at possibly finding a particular clade indigenous to a particular global area and developing several different vaccines that are geographically specific [64].

A vaccine that could slow the progression of HIV disease would save or prolong the lives of millions worldwide. The National Institutes of Health (NIH) researchers predict that an effective vaccine is at least 10 years away [65]. Health care workers do not have an increased risk for occupationally contracting HIV infection. Hepatitis B is much more easily transmitted in the health care setting than HIV.

Dentists, as a health professions group, have demonstrated very good compliance with the hepatitis B immunization program. It has been estimated that 71% of the dentists in the United States have been vaccinated against hepatitis B since the vaccine has become available [66]. If more of the population were inoculated, the overall benefit to health care workers would be greater potentially than if an HIV vaccine were to be discovered tomorrow [67]. In summary, oral health care providers should assess their needs for immunization based on the characteristics of their clinical work setting and their own risk-taking profile.

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