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CHAPTER 4

Infectious Disease Prevention

LEARNING OBJECTIVES

- Outline individual and community-based efforts that target infectious disease transmission.
- Explain the importance of personal hygiene methods such as handwashing, sanitary procedures for food preparation, and effective waste disposal in the prevention of food- and waterborne illness.
- Assess the efficacy of basic methods designed to decrease the transmission of vector-borne diseases.
- Assess the importance of blood screening in the prevention of infectious disease transmission.
- Explain the importance of vaccines and the goal of immunization.
- Differentiate between live attenuated, inactivated, and recombinant vaccines.
- Explain the concepts of isolation and quarantine.

Introduction

Prevention of infectious diseases can prove to be a complicated endeavor. Interventions such as handwashing are relatively simple, low cost, and easily implemented with availability of clean water, disposable towels, and soap. Others, however cost-effective they may be, may be more difficult to implement. Examples of such efforts include vaccinations and improved sanitation. Perhaps the most complicated are strategies to prevent sexually transmitted infections (STIs). This chapter focuses on vaccine-preventable diseases, handwashing, prevention of diarrheal illness, prevention of vector-borne diseases, blood screening, quarantine, and isolation.

Key Concepts

Preventing infectious diseases can be problematic at times. In the case of individual-level strategies, such as handwashing or the use of condoms, prevention is largely dependent on personal behavior. Community-based efforts such as accessible sanitary latrines, however, must be culturally appropriate for a given community. Mass vaccination programs may also be faced with their own challenges. In developing regions, maintenance of the "cold chain" (a system of storing and transporting vaccines at recommended temperatures from the point of manufacture to the point of use) may be difficult, if not impossible. In industrialized countries, mass vaccination programs may face "anti-vaxxers" who do not believe in vaccinating their children.

Vaccines

Immunization rates continue to lag in developing regions. Measles alone causes about half of all vaccine-preventable diseases worldwide. Numerous factors contribute to this situation. Civil unrest, humanitarian emergencies, antivaccination radical Islamists such as the Boko Haram in West Africa, inadequate public health infrastructure, difficulties in cold-chain maintenance, and inadequate partnerships between local governments and nongovernmental organizations (NGOs) all contribute to inadequate vaccination coverage in developing regions.

The word *vaccination* was coined in 1800 following the smallpox-prevention efforts of Edward Jenner in the 1790s. Vaccination has reduced infectious disease morbidity and mortality for more than two centuries. By the early 21st century, numerous vaccines had been developed, preventing a range of infectious diseases by bolstering antibody production in immunized individuals. Some vaccines prevent common childhood infections such as measles and mumps; others target STIs, such as human papilloma virus (HPV); and some protect the elderly against pneumococcal pneumonia. However, *availability* of vaccines does not necessarily translate into *access* to them. By the end of the 20th century, estimates suggest that vaccines might have prevented more than 11 million deaths. However, measles alone continues to kill about a million unvaccinated children annually, with roughly half of these deaths occurring in Africa.

What would the "perfect vaccine" look like? It would be able to actively enlist humoral host immunity via B cells that can begin to recognize antigens or pathogens after a single dose. Ideally, a single vaccine could protect against multiple pathogens (e.g., the MMR and MMRV vaccines). The perfect vaccine would also provide long-term—lifelong, if possible—protection against infection.

The immunogenicity of a perfect vaccine, that is, its ability to mount an immune response in an individual, does not tell the whole story. Such a vaccine should cause minimal adverse effects. It should also be easy to administer, either orally, by injection, or by inhalation, in a culturally appropriate manner. Moreover, a perfect vaccine would not require special handling, such as the need for constant refrigeration.

Immunity can occur actively or passively. **Active immunity** involves the host immune system's ability mount a protective immune response, often in the wake of vaccination. **Passive immunity** refers to short-lived immunity often conferred to newborns in utero or from breastmilk.

Types of Vaccines

The Centers for Disease Control and Prevention (CDC) in its *Epidemiology and Prevention of Vaccine-Preventable Diseases* ("The Pink Book") places vaccines into two general categories: live attenuated and inactivated. Other subtypes include recombinant, polysaccharide, and DNA vaccines. **Figure 4-1** provides a basic description of how vaccines interact with the host immune system to provide protection against infectious diseases. Adjuvants such as aluminum salts are sometimes added to vaccines to enhance their immunogenicity.

Live Attenuated Vaccines

Live attenuated vaccines (LAVs) harbor microorganisms that have been rendered nonpathogenic. This can be done in several ways, including laboratory culture, passing the microbe through a series of laboratory animal host tissues, and genetic manipulation. In other words, the LAV can spark an immune response without producing clinical disease. LAVs typically provoke a more robust host immune response than inactivated ones. The first LAV, the BCG (Bacille Calmette-Guérin) tuberculosis vaccine, was developed in the 1920s.

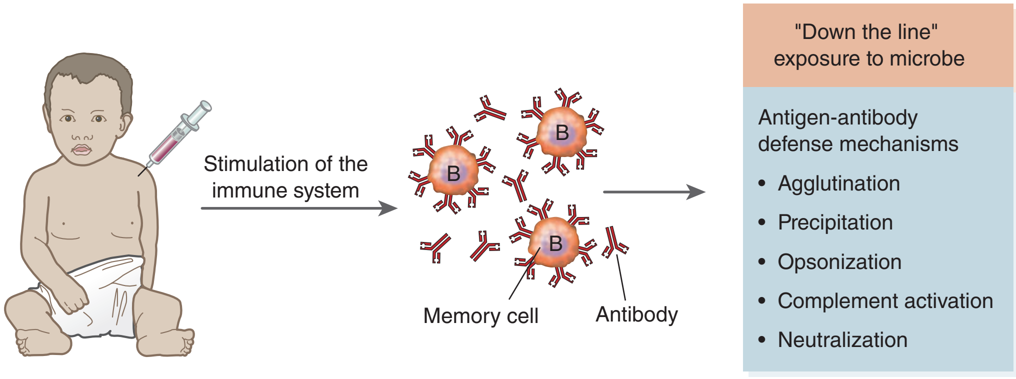


Figure 4-1 Vaccine–immune system interactions.

Courtesy of Shors T, ed. *Krasner's Microbial Challenge: A Public Health Perspective.* 4th ed. Burlington, MA: Jones & Bartlett Learning; 2020.

How LAVs Protect the Host

LAV microbes must be able to multiply in a host, thereby activating the host immune response. Given that they are able to produce humoral and cell-mediated immune responses, they can confer long-term, if not lifelong, host immunity. LAVs such as the oral polio vaccine (OPV), however, can potentially transfer the virus to susceptibles in domestic settings. The result, although rare, is vaccine-associated paralytic polio (VAPP). In light of this risk, the United States discontinued using OPV more than two decades ago.

LAV-Associated Transport Issues

LAVs typically require constant refrigeration. Without an unbroken "cold chain," the vaccines become unusable. In industrialized countries with readily available refrigeration facilities, this requirement seldom presents an issue. In developing countries with tropical climates, however, management of the cold chain may prove logistically difficult, if not impossible.

Inactivated Vaccines

Until recently, **inactivated vaccines (IVs)** harbored pathogens that had been "killed" by heating or chemicals such as formalin. IVs now utilize extracted protein or polysaccharide components derived from the pathogen itself. Vaccines such as those that prevent hepatitis A, influenza, polio, and rabies are good examples of IVs.

Recombinant Vaccines

Recombinant vaccines (RVs), unlike LAVs and IVs, are products of genetic manipulation of the specific pathogens they target. The FDA approved the first RV in the United States, the hepatitis B vaccine, in the mid-1980s. (A hepatitis E vaccine is presently under development.) The most recent FDA-approved RV, Shingrix, prevents shingles. Other RVs target HiB (*Haemophilus influenzae* type b), HPV, pertussis (part of the TDaP combined vaccine to prevent diphtheria and tetanus as well), pneumococcal disease, and meningococcal disease.

Polysaccharide Vaccines

Polysaccharide vaccines (PVs) utilize polysaccharides (long-chain sugar molecules) that appear on the surface capsules of bacteria. At present, PVs are available for pneumococcal pneumonia, bacterial meningitis, and typhoid fever. A polysaccharide HiB vaccine is no longer available in the United States.

DNA Vaccines

DNA vaccines (DNAVs) utilize DNA coding for a specific part of the target pathogen. A number of DNAVs are currently under development to prevent malaria, tuberculosis, and West Nile virus. These vaccines have numerous advantages. They tend to be less expensive to manufacture and are thereby more cost-effective. As in the case of LAVs, the immune responses that DNAVs prompt may also help to confer lifelong immunity. Of perhaps the greatest importance, they appear to be very stable, eliminating the need for strict attention to cold-chain protocols.

DNAVs are not without their disadvantages, however. They do have potential adverse effects. Among them are chronic inflammation at the infection site and possible integration into host chromosomes, which may interfere with actions of tumor-suppressor genes.

Other Vaccine Issues

Who Should Not Receive Vaccinations?

Not everyone should receive routine vaccinations. This is the case with patients with known allergies to the vaccine or its components and those who are seriously ill. Patents who are immunosuppressed (e.g., HIV-positive or pregnant) should not receive LAVs.

How Effective Are Vaccines?

Vaccine efficacy (VE), a concept that Britons Major Greenwood (1880–1949) and George Yule (1871–1951) outlined in 1915, quantifies the proportion of a given population that must be vaccinated to achieve **herd immunity**. Its calculation, expressed as a percentage, assumes that infectives, immunes, and susceptibles interact randomly (see **Box 4-1**). A vaccine that has an efficacy of 90%, for example, would be a very effective vaccine indeed.

Box 4-1 Calculation of Vaccine Efficacy (VE)

VE = (AR Unvaccinated − AR Vaccinated)/(AR Unvaccinated) × 100

Modified from Jekel J, Katz DL, Elmore JG, et al. *Epidemiology, Biostatistics, and Preventive Medicine*. 3rd ed. Philadelphia, PA: Saunders; 2007.

The Public Health Impact of Vaccines

The impact of vaccines on public health is incalculable. Few other public health initiatives, except for improved sanitation and access to potable water perhaps, have had such a positive effect on human as well as veterinary health. Routine vaccination of domestic animals such as dogs, for example, has significantly reduced the number of human rabies cases. **Table 4-1** provides the recommended vaccine schedules for the United States as of 2018.

Poliomyelitis Vaccines

The polio vaccine has virtually eliminated poliomyelitis in many parts of the world. Few infectious diseases, owing to the polio-stricken President Franklin Roosevelt and the fundraising efforts of the March of Dimes, have been placed so squarely in the public eye. Roosevelt founded the National Foundation for Infantile Paralysis in September 1937, and it was renamed as the March of Dimes several months later in January 1938 (**Figure 4-2**). Throughout the 1940s, the incidence of paralytic polio tripled from less than 12 cases per 100,000 in 1940 to roughly 37 cases per 100,000 in 1952. Once the vaccine appeared in the mid-1950s, the number of cases plummeted (see **Figure 4-3**).

The Salk Vaccine

The FDA licensed American virologist Jonas Salk's (1914–1995) inactivated intramuscular polio vaccine in 1955. Following a nationwide

Table 4-1 Recommended Vaccination Schedules, 2018

Vaccine	Age	First Dose	Second Dose	Third Dose	Fourth Dose	Fifth Dose	Booster
DTaP	0–18 years	2 months	4 months	6 months	15–18 months	4–6 years	
Hepatitis A*	0–18 years	12–15 months	19–23 months				
	19+ years	Anytime	6–12 months later				
Hepatitis B*	0–18 years	Birth	1–2 months	6–16 months			
	19+ years	Anytime	1 month later	6 months later			
Hib	0–18 years	2 months	4 months	6 months[1]	12–15 months		
HPV	9–14 years OR	Anytime	6–12 months later				
	15–26 years	Anytime	1–2 months later	6 months later			
Influenza	6+ months	Anytime	Yearly				
IPV	0–18 years	2 months	4 months	6–18 months	4–6 years		
MenACWY*	0–18 years	11–12 years	16 years				Every 5 years
	19+ years	Anytime	8 weeks later				Every 5 years
MenB	16–23 years	Anytime	6 months later				
MMR*	0–18 years	12–15 months	4–6 years				
	19–61 years	Anytime					
PCV13[a]	0–18 years	2 months	4 months	6 months	12–15 months		
	65+ years	Anytime					
PPSV23[b]	0–18 years	2 months	4 months	6 months	12–15 months		
	65+ years	1 year after PCV13					

(*continues*)

Table 4-1 Recommended Vaccination Schedules, 2018 (*continued*)

Vaccine	Age	First Dose	Second Dose	Third Dose	Fourth Dose	Fifth Dose	Booster
Rotavirus	0–18 years	2 months	4 months	6 months[2]			
Shingles	50+ years OR	Anytime	2–6 months later				
	60+ years	Anytime					
Tdap*	0–18 years	11–12 years					Every 10 years
	19+ years	Anytime					Every 10 years
Varicella*	0–18 years	12–15 months	4–6 years				
	19+ years	Anytime	4–8 weeks later				

*Additional vaccinations not required 19+ years if previously administered, not including boosters.
[1]6-month vaccination required only with four-dose series.
[2]6-month vaccination required only with three-dose series.
[a]Pneumococcal vaccine.
[b]Pneumococcal vaccine.

Modified from CDC. Table 1. Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger, United States, 2019. https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html. Accessed February 3, 2020.

Figure 4-2 Early March of Dimes Poster, c. 1945.

In Memoriam: Donald Anderson, First Poster Child, 1940–2014, March of Dimes. https://www.marchofdimes.org/news/in-memoriam-donald-anderson-first-poster-child-1940-2014.aspx. Accessed January 3, 2019.

immunization campaign, the number of polio cases fell by 90% in the United States. As the number of cases dropped, polio-associated mortality fell as well. Nonetheless, the Salk vaccine failed to spur a sufficient immune response that fully protected children against infection. Outbreaks continued to occur periodically even among fully vaccinated children.

The Sabin Vaccine

The American medical researcher Albert Sabin (1906–1993) developed a polio vaccine, an oral LAV, which was licensed in 1961. Within a decade it became the preferred polio vaccine. Cases continued to decline sharply; by 1964 the United States reported fewer than 60 polio cases nationwide. Similar drops in paralytic polio cases followed, falling from more than 2,500 in 1960 to barely 60 just 5 years later.

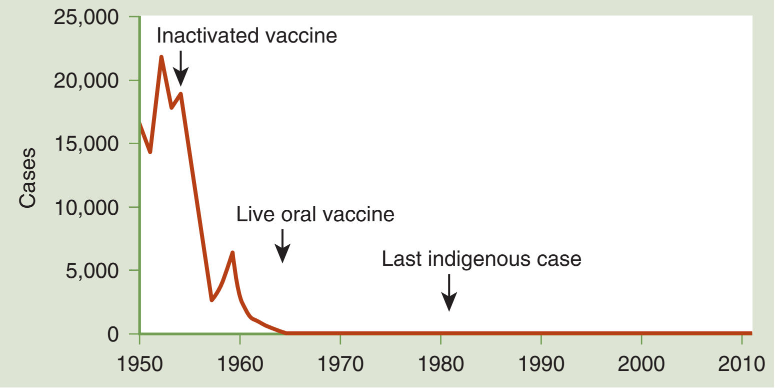


Figure 4-3 Polio in the United States, 1950–2011.

CDC, National Notifiable Disease Surveillance System. Poliomyelitis. https://www.cdc.gov/vaccines/pubs/pinkbook/polio.html. Accessed February 3, 2020.

Vaccine-associated paralytic polio (VAPP), first documented in the early 1960s, sometimes occurs as a side effect to vaccination with this vaccine. Although VAPP is extremely rare, estimates suggest an incidence of about 3.4 per 1,000,000. Immunocompromised patients face significantly higher risk. The polio vaccination protocol in the United States changed in the late 1990s, shifting from an entirely OPV schedule to one with oral and intramuscular administration. This modification has virtually eliminated VAPP cases in the United States (see **Figure 4-4**). The last documented case of VAPP in the United States occurred in 1999.

Measles Vaccines

Measles remained a common childhood illness in the United States until the introduction of a measles vaccine in early 1960s. The number of cases averaged more than 500,000 cases annually; about 500 of them proved fatal. Epidemics typically occurred every 2 or 3 years, producing an estimated 3.5 million cases. During this time, more than half of American children younger than 5 years had contracted measles, and more than 90% had contracted measles by the time they reached 15 years. The incidence of measles cases typically peaked during the first months of school attendance.

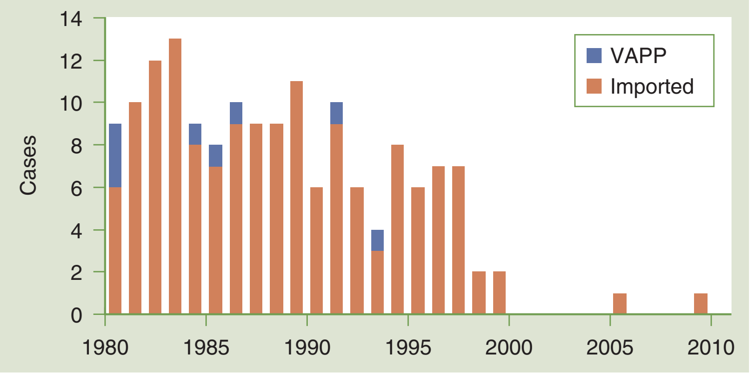


Figure 4-4 VAPP cases in the United States, 1980–2010.

CDC, National Notifiable Disease Surveillance System. Poliomyelitis. https://www.cdc.gov/vaccines/pubs/pinkbook/polio.html. Accessed February 3, 2020.

The first measles vaccine in the United States was the Edmonston B strain, an LAV, approved in 1963. Several years later in 1968, the Enderson-Edmonston strain, also an LAV, was introduced. The public health impact of the measles vaccine has been enormous. Incidence of the disease has dropped approximately 99% since its introduction (see **Figure 4-5**). Gone also are the 2- to 3-year epidemic cycles.

Pockets of poor measles vaccination rates remain in the United States. In poverty-stricken urban areas, for example, vaccination rates are below average among Hispanic and African American children. Poor vaccination rates also occur among groups whose religious or philosophical beliefs compel them to refuse vaccinations of all kinds for themselves or their children—not least for measles. As of 2018, the majority of U.S. states allowed personal or religious belief exemptions for routine childhood vaccinations. This policy resulted in hundreds of measles cases during the first half of 2019 alone. Hence, the "anti-vaxxers." Some critics have framed this as "vaccine hesitancy," which World Health Organization (WHO) officials deem to be one of the most important health issues of our time.

Measles outbreaks sometimes occur among *vaccinated populations*, however. One occurred in the mid-1980s among individuals who had previously received the recommended doses of the measles vaccine. The CDC published a revised immunization schedule, one that recommended reimmunization of children as they entered grammar school and middle school. Another outbreak followed several years later in the late 1980s and early 1990s. More than 1,800 cases were reported in 1989, nearly 28,000 cases in 1990, and almost 10,000 cases in 1991. CDC officials blamed the outbreak on poor compliance with the recently revised administration schedule.

Haemophilus influenzae Type B (HiB) Vaccines

Prior to the introduction of the HiB vaccine, roughly 1 in every 2,000 children developed *Haemophilus influenzae* infections before 5 years of age. Among these children, nearly two-thirds developed bacterial meningitis; 10% died. Survivors often faced sequelae such as hearing loss and cognitive defects.

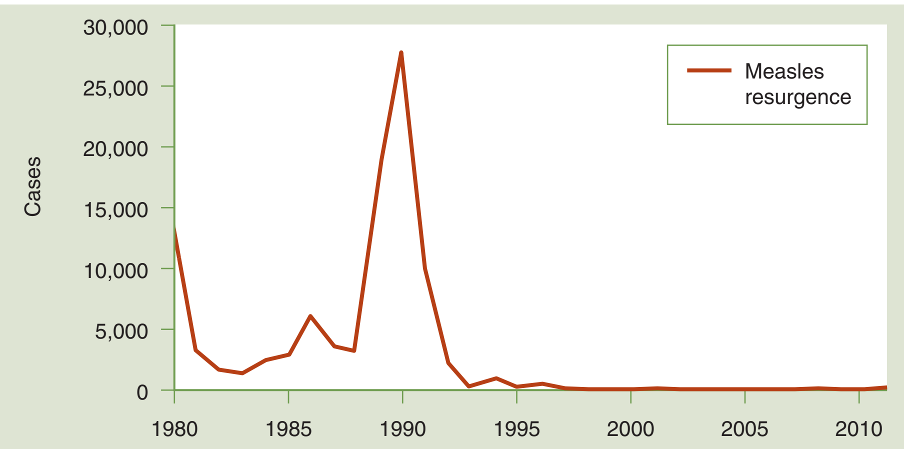


Figure 4-5 Measles cases in the United States, 1980–2011.

CDC, National Notifiable Disease Surveillance System. Measles. https://www.cdc.gov/vaccines/pubs/pinkbook/meas.html#. Accessed February 3, 2020.

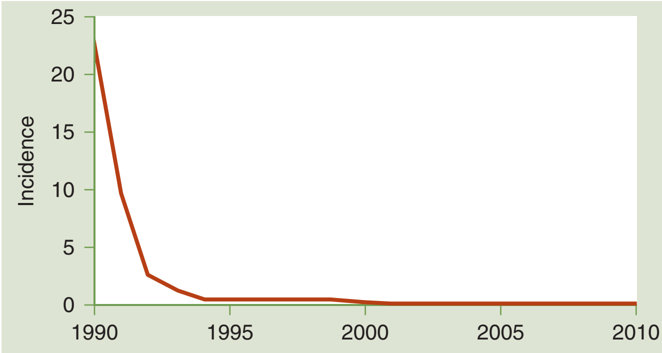


Figure 4-6 Incidence of invasive HiB disease per 100,000 children younger than 5 years of age: 1990–2010.

CDC. *Haemophilus influenzae* type b, Secular Trends in the United States. https://www.cdc.gov/vaccines/pubs/pinkbook/hib.html#trends. Accessed February 3, 2020.

The introduction of an HiB vaccine in 1985, however, significantly decreased the number of bacterial meningitis cases by 95% within a decade (see **Figure 4-6**).

The first HiB vaccination licensed in the United States in 1985 targeted children 2 years and older; the vaccine had proven poorly immunogenic prior to that age. A subsequent HiB vaccine appeared in 1987 for children older than 18 months. Another vaccine soon followed, this one approved for children as young as 2 months. By the late 1990s, HiB vaccination rates in the United States soared to more than 90%. Invasive *Haemophilus influenzae* disease, such as bacterial meningitis, dropped from more than 30 per 100,000 to less than 5 per 100,000.

Vaccines and Infectious Disease Eradication

The phenomenon of herd immunity makes immunization of an entire population unnecessary. The number of people who must be vaccinated to achieve herd immunity reflects several factors about the particular infectious disease, such as the nature of the infection per se, its transmission rate, the length of its infectious period, and the degree to which members of a population interact with one another. Ultimately, if susceptibles can avoid infectious cases—especially if there are relative few of them in a population—then they are likely to escape infection.

Factors Associated with Vaccine-Based Infectious Disease Eradication

The nature of the infectious disease makes a huge difference in elimination efforts. The ease that clinicians can diagnose and treat the infection is also important. Finally, the presence or absence of an infection's seasonality allows a useful way to predict the epidemics and pandemics of infections such as influenza more easily.

The nature of the particular pathogen is another important factor. The variola major virus that causes smallpox has a narrow host range (humans only), and thus was far easier to eradicate than it would be to eliminate a disease with a very broad host range, such as rabies, which is caused by a Rhabdoviruses that infects mammals. Pathogens that have a single serotype and a short incubation period are also easier to eradicate than those that do not. Also of importance is the ease and mode of transmission. Is the pathogen waterborne? Foodborne? Airborne? Is it spread by bodily fluids?

The characteristics of the potential host(s) and target population(s) provide another important element in vaccine-based infectious disease eradication. Sufficient vaccination levels, combined with a low probability of reinfection, good vaccine efficacy, and the absence of pathogen-shedding are a good start. Unless health officials have community buy-in, they may have difficulty convincing the target population to consent to vaccination.

The nature of the vaccine is paramount. The ideal vaccine should have a simple dosing schedule and provide long-term protection of the host. Without the need for the cold chain, the logistics of mass immunization programs become far less complicated. Nor should there be any cross-vaccination interaction(s); health officials should be able to administer several vaccines in a single clinic visit, thus avoiding the need for repeated visits. Finally, vaccines should cause minimal adverse effects.

Infectious Disease Prevention at the Individual Level: The Importance of Handwashing

An individually based intervention as simple as handwashing can significantly reduce infectious disease transmission. Thorough handwashing after contact with human and animal waste or unwashed or poorly cooked food is a good example. Handwashing may not be as "simple" a task as it may seem, however. Unless clean water, disposal paper towels, and soap are available, the best efforts may be for naught. Although hand-rinsing with clean water is a good start, water alone may not remove all microscopic contaminants. Soap and water not only disinfect the skin better than water alone, but soap helps to remove oils and other organic matter from the skin. Vigorous handwashing with soap and clean water remains the *sine qua non* of infection control in general. Although alcohol-based hand sanitizers offer a convenient handwashing option where clean soap and water are not readily available, they do not necessarily improve handwashing rates.

Handwashing is a two-step process. The washed hands—washed well, one hopes—require proper drying with clean towels. Contaminated hand towels can quickly reverse even the most scrupulous handwashing efforts. Hence, disposable paper towels are a good bet. Although air dryers (where electricity is available) offer a convenient option when clean paper towels are unavailable, their aerosol plumes can disperse contaminants into the ambient environment.

Observational studies of handwashing have highlighted what a tough sell this apparently simple behavior can be. In developing regions appropriate handwashing behavior ranges from none at all to roughly one-third of the time. These findings do not reflect so much a *lack* of available soap but its *use* for purposes other than handwashing (e.g., laundering, cleaning, and bathing).

The **Aquamor program** implemented in Zimbabwe and other African countries highlights a successful intervention to improve handwashing behaviors. Using common items such as empty water bottles or soft drink cans, a 3-millimeter nail, and piece of wire to suspend the container, one can fashion a handwashing device that is environmentally- and user-friendly. When people need to wash their hands (such as after visiting the toilet), they simply fill the container and place the soaped hands beneath the thin stream of water. The device is simple, effective, and virtually cost-free.

The WHO also has aggressively promoted routine handwashing. On October 15, 2008, the WHO launched **Global Handwashing Day (GHD)** to promote handwashing among school-age children. With the help

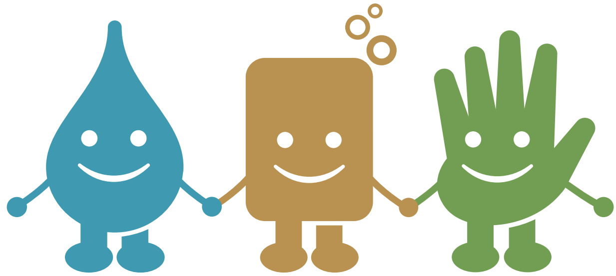


Figure 4-7 Global Handwashing Day Promoted by WHO.

WHO. Global Handwashing Partnership. https://www.paho.org/hq/index.php?option=com_content&view=article&id=13776:global-handwashing-day-2017&Itemid=42451&lang=pt. Accessed January 5, 2019.

of international stakeholders such as corporations, universities, and government agencies, October 15th remains Global Handwashing Day (see **Figure 4-7**). **Box 4-2** provides an example of a handwashing intervention implemented in Kenyan schools.

Prevention of Foodborne Infections

Foodborne infections rank globally as one of the most common type of maladies. According to WHO estimates, some 600 million people develop them each year. Among these cases, roughly 420,000 succumb; of these deaths, roughly 125,000 (just shy of a third) occur in children younger than 5 years of age.

The WHO began a foodborne infections initiative in 2001 to address this global problem. Enlisting more than 100 countries, officials launched its **Five Keys to Safer Food (FKSF)** program (see **Figure 4-8**) to educate consumers and food handlers about foodborne disease prevention. Sadly, some—if not all—of these principles may prove impractical in regions that lack access to adequate fresh water, soap, and refrigeration.

Keep the Food Clean

Clean food is fundamental to the FKSF. The best way to protect food items from contaminated surfaces is by keeping them and their preparation areas as clean as possible. This requires not only aggressive handwashing prior to, during, and after food preparation, but also routine disinfection of *food preparation surfaces* such as cutting boards, countertops, and cooking utensils.

Box 4-2 A Handwashing Intervention in Kenyan Schools

Investigators assessed whether easy access to soap improved handwashing and reduced *E. coli* hand contamination among primary-school students. They conducted structured observations of handwashing after latrine use in 60 Kenyan schools and collected hand rinse samples.

Handwashing with soap (HWWS) was significantly higher in schools that had received adequate supplies of soap (32%) and latrine cleaning materials (38%). Among controls the proportion was only 3%. Handwashing rates did not differ by gender. Although investigators did not find significant reductions in *E. coli* contamination, they did conclude that easy access to soap *per se* increased handwashing rates.

Modified from Saboori S, Greene LE, Moe CL, et al. Impact of regular soap provision to primary schools on hand washing and *E. coli* hand contamination among pupils in Nyanza Province, Kenya: a cluster-randomized trial. *Am J Trop Med Hyg*. 2013;89(4):698–708.

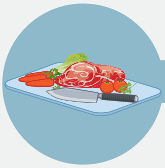
Five Keys to Safer Food

Keep clean

- Wash your hands before handling food and often during food preparation
- Wash your hands after going to the toilet
- Wash and sanitize all surfaces and equipment used for food preparation
- Protect kitchen areas and food from insects, pests, and other animals

Why?

While most microorganisms do not cause disease, dangerous microorganisms are widely found in soil, water, animals, and people. These microorganisms are carried on hands, wiping cloths, and utensils—especially cutting boards—and the slightest contact can transfer them to food and cause foodborne diseases.

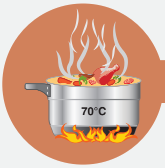


Separate raw and cooked

- Separate raw meat, poultry, and seafood from other foods
- Use separate equipment and utensils such as knives and cutting boards for handling raw foods
- Store food in containers to avoid contact between raw and prepared foods

Why?

Raw food, especially meat, poultry, and seafood and their juices, can contain dangerous microorganisms which may be transferred onto other foods during food preparation and storage.

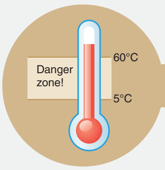


Cook thoroughly

- Cook food thoroughly, especially meat, poultry, eggs, and seafood
- Bring foods like soups and stews to boiling to make sure that they have reached 70°C . For meat and poultry, make sure that juices are clear, not pink. Ideally, use a thermometer
- Reheat cooked food thoroughly

Why?

Proper cooking kills almost all dangerous microorganisms. Studies have shown that cooking food to a temperature of 70°C can help ensure it is safe for consumption. Foods that require special attention include minced meats, rolled roasts, large joints of meat, and whole poultry.



Keep food at safe temperatures

- Do not leave cooked food at room temperature for more than 2 hours
- Refrigerate promptly all cooked and perishable food (preferably below 5°C)
- Keep cooked food piping hot (more than 60°C) prior to serving
- Do not store food too long even in the refrigerator
- Do not thaw frozen food at room temperature

Why?

Microorganisms can multiply very quickly if food is stored at room temperature. By holding at temperatures below 5°C or above 60°C, the growth of microorganisms is slowed down or stopped. Some dangerous microorganisms still grow below 5°C.

Use safe water and raw materials

- Use safe water or treat it to make it safe
- Select fresh and wholesome foods
- Choose foods processed for safety, such as pasteurized milk
- Wash fruits and vegetables, especially if eaten raw
- Do not use food beyond its expiry date

Why?

Raw materials, including water and ice, may be contaminated with dangerous microorganisms and chemicals. Toxic chemicals may be formed in damaged and moldy foods. Care in selection of raw materials and simple measures such as washing and peeling may reduce the risk.

Figure 4-8 The WHO's Five Keys to Safer Food.

World Health Organization. The Five Keys to Safer Food Programme. http://www.who.int/foodsafety/areas_work/food-hygiene/5keys/en/. Accessed January 5, 2019.

Separate the Foods: Raw and Cooked

The FKSF also emphasizes the importance of separating cooked and uncooked foods. Consider, for example, preparing raw poultry on a kitchen counter. You then fail to disinfect the cutting-board surfaces or the cutlery. Having sliced the poultry, you then dice fruit or raw vegetables on the same, likely contaminated, surface. The possibility of cross-contamination between the poultry and the fruit, although obvious, can easily be overlooked.

Cook the Foods Thoroughly

Proper cooking temperatures are another must. Meats, whether solid or ground, require a *minimum* internal temperature of 70°C (158°F). Ideally, a meat thermometer should be used. As an additional precaution, the juices of poultry and pork items should run *clear,* not pinkish. Liquid food items such as soups and stews should be boiled thoroughly.

Prepare and Store Foods at Proper Temperatures

Never thaw foods at room temperature. Many common foodborne pathogens flourish at temperatures between 5°C (41°F) and 60°C (140°F). The rule of thumb is this: hot foods should remain hot, and cold foods should remain cold. Foods that sit for more than 2 hours can easily become a Petri platter, as it were.

Use Safe Water to Wash Food Items Prior to Preparation

Clean water is vital for washing raw foods prior to preparation. If a water source is of questionable quality, it should be boiled briskly at 60°C (140°F) or higher for at least 12 minutes or infused with a chlorinated solution (such as bleach) in a ratio of 5 drops per liter of water.

Prevention of Diarrheal Illness

Community-based diarrhea prevention efforts begin with access to clean drinking water. As in the case of foodborne illness, waterborne infectious diseases are often associated with fecal contamination. Common pathogens include norovirus, *E. coli*, *Vibrio cholerae*, *Giardia lamblia*, and *Entamoeba histolytica*. WHO officials estimate that more than 2.5 million people lack access to basic sanitation. Roughly 783 million live without access to potable water. The most severely affected populations are in sub-Saharan Africa and Southeast Asia.

The **United Nations Millennium Development Goals (UNMDGs)**, a part of the United Nations Millennium Declaration of 2000, address a number of broad areas of global health issues (see **Figure 4-9**). Poor sanitation and contaminated water sources are of particular concern. By 2015 the UN had hoped to reduce the proportion of people without proper sanitation and access to clean water by one-half. At present, however, inadequate sanitation and access to potable water still remain pressing issues in developing regions.

Community-based interventions such as sanitary latrines must be culturally acceptable. The use of **SanPlats** (short for "sanitation platforms") in developing regions is a good example (see **Figure 4-10**). Their low-cost, standardized design, and easy maintenance make them ideal for areas of the world that lack proper sanitation facilities. A **VIP SanPlat**, one that has a screened ventilation port mounted on its roof, is also available.

Figure 4-9 United Nations Sustainable Development Goals.

Reprinted with permission from Sustainable Development Goals (SDGs), United Nations. http://un.org.au/campaigns/major-un-campaigns/2015-time-for-global-action/. Accessed January 5, 2019.

Figure 4-10 A sanitation platform (SanPlat).

https://sanplat.files.wordpress.com/2015/09/family_sanplat.jpg. Accessed January 5, 2109.

Impact of Sanitation Improvements

Interventions such as SanPlats can significantly improve quality of life. Not only can they reduce the incidence of diarrheal disease, they can provide collateral benefits as well. Healthy children, for example, are more likely to attend school regularly than sick ones and to have better physical and cognitive development. SanPlat proponents have also noted that the privacy they provide when properly surrounded by partitions has reduced sexual violence against young girls.

Sanitation initiatives are cost-effective, as they help to improve economical productivity. WHO estimates suggest that sanitation initiatives yield about $6.00 for every $1.00 invested. Some investigators have suggested these programs also empower women by improving literacy rates and increasing tourism.

Demands of Sanitation Initiatives

Sanitation-improvement programs, however, can prove complicated. Their sustainability requires substantial resources in terms of money, labor, and infrastructure. Maintenance of such improvements—not least SanPlats—may also have low priority in regions fraught with civil unrest, famine, and epidemic disease.

Safe water initiatives face numerous hurdles to be sure. They must address basic issues of water *quality* and *accessibility*. Are water sources conveniently located, or do water-haulers—often women tasked with domestic duties—have to walk a kilometer or more to draw water? (One should note that a *single* liter of water weighs 1 kg.) Are seasonal issues associated with the availability of potable water? **Afridev hand pumps** provide a low-cost, easily maintained, sustainable solution to this problem (see **Figure 4-11**).

Figure 4-11 Afridev hand pump.

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Host Nutritional Status and Prevention of Diarrheal Illness

Conflicting evidence exists concerning the effect of malnutrition on diarrheal-illness risk. Some studies suggest an association between the two, whereas others do not. Agreement does exist on one finding, however: malnourished children who develop diarrheal disease face attacks of longer duration and greater severity. Vitamin A and zinc supplements, for example, may reduce diarrhea-associated mortality.

Prevention of Vector-Borne Infectious Diseases

Vector-borne diseases such as malaria have plagued humankind for thousands of years. It was not until the turn of the 20th century that investigators recognized the role that insects such as fleas, mosquitoes, and ticks play in the transmission of infectious diseases. Community-based education efforts about mosquito-breeding sites often teach school-aged children to spot breeding places and how to disrupt them if possible. These youngsters can then teach their friends and family members about the art of tipping birdbaths, emptying discarded tires, upending buckets, and so on—a simple, but effective strategy (see **Figure 4-12**).

Birdbath-tipping and bucket-upending are a good start at mosquito control. Potential breeding sites such as tire ruts, ponds, and puddles, however, might not be so amenable to such simple interventions. More sophisticated strategies such as larvivorous fish, bacterial applications, and insecticides may be necessary.

One strategy targets the mosquito larvae with insecticides such as malathion. This method involves spraying of breeding sites such as ponds manually—site by site—or aerially with aircraft (where available). The latter can

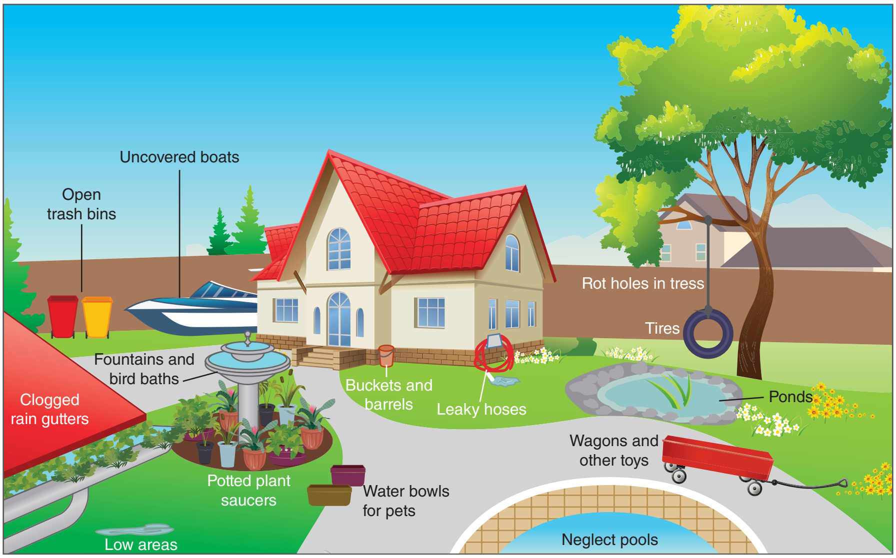

Figure 4-12 Community-based mosquito control strategies.

Center for Disease Control and Prevention.

treat large geographical areas. Another option, one that targets adult mosquitoes, is **insecticide residual spraying (IRS)**, applied to interior and exterior landing surfaces. IRS has proven especially helpful in malaria control programs.

More ecofriendly strategies are also available, such as doughnut-shaped cakes laden with ***Bacillus thuringiensis israelensis* (BTI)**. This method works best in small bodies of water such as ponds and birdbaths (see **Figure 4-13**). Polystyrene beads offer another environmentally-friendly option. They not only suffocate mosquito larvae and pupae, but they also inhibit egg-laying activity. A more practical option for large bodies of water, however, is the application of larvivorous fish such as the *Gambusia affinis* (see **Figure 4-14**).

Personal protective strategies such as insecticide-treated bed nets, DEET-based insect repellant, and long-sleeved clothing are useful at the individual level but require consistent use. Moreover, individuals must

Figure 4-13 Biological-based mosquito control efforts.

© John Davenport/San Antonio Express-News/ZUMA Press/Alamy Stock Photo

Figure 4-14 A *Gambusia* spp. prepares to ingest a mosquito larva.

CDC. https://phil.cdc.gov/details_linked.aspx?pid=4958. Accessed February 3, 2020.

maintain the integrity of their bed nets by retreating them periodically, checking them for tears, and using them every night.

Blood Donor Screening and Infectious Disease Prevention

Screening of donor blood is used to prevent **transfusion-transmissible infections (TTIs)** such as hepatitis B and C, HIV/AIDs, and other bloodborne pathogens. Globally, about 112.5 million blood donations are collected each year. More than half of them occur in industrialized countries.

American Red Cross (ARC) Protocols

The American Red Cross (ARC) routinely screens for numerous bloodborne pathogens. These include *Trypanosoma cruzi*, the parasite that causes American trypanosomiasis (Chagas disease); viruses such as hepatitis B and C, human T-lymphocytic virus types I and II, and West Nile virus; and bacterial pathogens such as *Treponema pallidum*, the causative agent of syphilis.

Determination of potential donor eligibility begins with a general health history, one that inquires about recent travel, sexual behavior, and intravenous (IV) drug use. The screening tool, the **Uniform Donor History Questionnaire (UDHQ)**, is intended to flag potential medical, behavioral, or geographic factors associated with TTIs. The most common flags are hepatitis B, IV drug use, multiple sex partners, and travel history. One should note that WHO officials consider *unpaid volunteers* to be ideal donors. They may be less likely to falsify health information, such as a history of IV drug use or high-risk sexual behaviors, than paid donors who might hope to gain some type of monetary reward. An abbreviated UDHQ is used for frequent, qualified donors.

Quarantine and Isolation in Infectious Disease Prevention

The goal of **quarantine** and **isolation** measures is very simple: to prevent the spread of infectious disease(s) in a population. Their use is hardly a recent phenomenon (see **Figure 4-15**). In the midst of the plague that bears his name, Emperor Justinian ordered city officials to block entry of refugees into Roman cities. During the Black Death of the mid-14th century, authorities attempted to halt its spread by refusing harbor to ships and blockading entrance into towns. A century ago the Spanish flu prompted medical authorities to sequester cases for fear that they would exacerbate the spread of the disease.

Isolation

The word *isolation* is derived from the Latin, *isolatus*, meaning "made into an island." Ill persons may isolate themselves by avoiding school or work out of concern for the health of friends, classmates, or colleagues; healthy persons, in turn, may avoid individuals who are coughing, sneezing, or otherwise appear unwell. These are all behaviors that amount to **social distancing**, a deliberate—and *voluntary*—attempt to consciously separate infecteds from susceptibles. A common cold

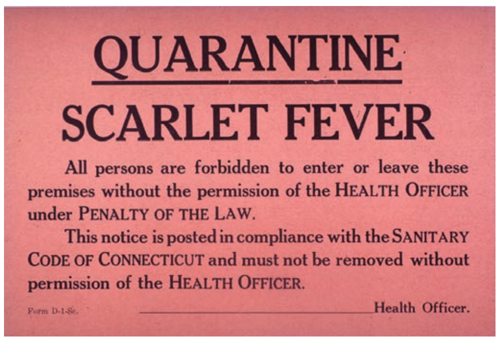

Figure 4-15 Scarlet fever quarantine, c. 1910.

Courtesy of NLM/NIH

sufferer who routinely greets others with a handshake might politely decline out of concern of "giving" someone his or her cold. The bottom line? It's an *informal* social courtesy.

Quarantine

In contrast, there is little, if anything, voluntary or informal about mandatory quarantine measures. The English word *quarantine*, derived from the Latin, *quarentena*, refers historically to the 40-day period that, according to Christian texts, Jesus spent alone—and isolated—in the wilderness. Fearing the appearance of plague victims, 14th-century Italian harbormasters forbade merchant ships to dock or passengers to come ashore until *quaranta giorni*—40 days—had passed. Four centuries later quarantine continues to restrict the interaction of infecteds who might infect others. In a very real sense, it represents a "wait-and-see" strategy to determine whether a suspected infective will develop a specific infection.

Steps in the Quarantine Process

The quarantine process starts with **case finding**. The goal of this stage is identification of infectives and suspected infectives in order to treat, isolate, and quarantine them. The identification of the index or primary case, sometimes referred to as "patient zero," is the ultimate aim. In some situations, it may be impossible to ascertain who this individual is. Any cases that result from contact with the index case are called secondary cases.

Contact tracing is the next step. This strategy works best with infectious diseases of low prevalence. It focuses on the person(s) with whom a confirmed case may have had contact (e.g., household members in the case of active tuberculosis or sexual partners). Some contacts may ultimately be quarantined.

Contact tracing has its limitations. In STI investigations, individuals may worry about potential stigmatization that may deter infectives from notifying their contacts; identified contacts may refuse testing or treatment. Asymptomatic cases may escape detection altogether.

The Social Impact of Quarantine Measures

Quarantine measures may bring normal day-to-day activities to a halt. Indeed, the potential extent of quarantine measures may appear rather draconian. Local, state, and federal public health authorities may close schools, restrict public gatherings such as religious services, and/or discontinue access to mass transit. Amidst the alarming increase in measles cases in New York in early 2019, for example, public health officials declared public health emergencies in a number of counties. One was Rockland County, where they prohibited anyone either diagnosed with measles or exposed to someone suffering from the infection from visiting any indoor or outdoor public settings for up to 21 days except for medical treatment, emergencies, or court appearances. Officials also mandated that these individuals share any and all pertinent measles-related information with Rockland County public health authorities.

Nor are such measures a new phenomenon in the United States. Shortly after the turn of the 20th century, Massachusetts officials jailed Henning Jacobson for refusing compulsory vaccination. He was fined $5.00 (roughly $150 today). Jacobson believed that the state had infringed upon his personal liberties, in this case to refuse mandatory smallpox vaccination. By late 1904, his case (***Jacobson v. Massachusetts***, 197 US 11, 1905) had reached the United States Supreme Court. Speaking for the Court early the next year, Justice John Marshall Harlan presented the findings of the 7-2 opinion against Jacobson. The State of Massachusetts, he argued, might well be justified in its authority to limit an individual's personal liberty if his or her actions might somehow threaten the well-being of the general public.

The Model State Emergency Health Powers Act (MSEHPA), passed by Congress in 2001 shortly after 9/11, is a good example of the government's broad quarantine authority. The MSEHPA provides assistance to *states* to protect the public's health during emergencies associated with bioterrorist acts. The act has sparked considerable criticism by civil libertarian groups.

The Effectiveness of Isolation and Quarantine

The effectiveness of isolation and quarantine is not always clear. Real-time trials are obviously not an option. Moreover, isolation and quarantine work best if the infectious period of an illness occurs *after* rather than *before* the appearance of symptoms. *Voluntary* "social distancing" relies entirely on the willingness of ill individuals to avoid interactions with others; nonvoluntary quarantine measures require diligent identification and sequestration of suspected cases and may raise civil liberties issues, as in the *Jacobson* case.

Conclusion

Prevention of infectious diseases can sometimes prove a complicated undertaking. The weakest link in prevention efforts may be the members of a population themselves. Strategies can address individual-level disease prevention, such as safe food preparation, or community-level disease prevention, such as vector control. Nor does infectious disease prevention need to be complicated, as evidenced by handwashing.

Key Terms

active immunity
Afridev hand pumps
Aquamor program
Bacillus thuringiensis israelensis (BTI)
case finding
DNA vaccines (DNAVs)
Five Keys to Safer Food (FKSF)
Global Handwashing Day (GHD)
herd immunity
inactivated vaccines (IVs)
insecticide residual spraying (IRS)
isolation
Jacobson v. Massachusetts
live attenuated vaccines (LAVs)
passive immunity
polysaccharide vaccines (PVs)
quarantine
recombinant vaccines (RVs)
SanPlats
social distancing
transfusion-transmissible infections (TTIs)
Uniform Donor History Questionnaire (UDHQ)
United Nations Millennium Developmental Goals (UNMDGs)
vaccine efficacy (VE)
VIP SanPlat

Review Questions

1. Identify at least three individual actions that can prevent the spread of infectious diseases.
2. Summarize at least three community-based actions that help to prevent the spread of infectious diseases.
3. Discuss the importance of handwashing, sanitary procedures for food preparation, and effective waste disposal in the prevention of food- and waterborne illness.
4. Identify at least three methods used to halt the transmission of vector-borne disease.
5. Explain the importance of blood screening in preventing bloodborne infections.

6. Compare and contrast social distancing and quarantine measures.
7. Explain the purpose of the Model State Emergency Health Powers Act (MSEHPA).
8. Describe the characteristics of the "perfect" vaccine.
9. Describe the advantages and disadvantages of recombinant vaccines.
10. List the five keys principles for safer food.

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