e-ISSN: 2248-9126
Vol 2|Issue 2| 2012 |63-74. Print ISSN: 2248-9118

Indian Journal of Pharmaceutical Science & Research

www.ijpsrjournal.com

AN OVERVIEW ON INFECTIOUS DISEASE

Subash Vijaya Kumar[1]*, G. Damodar[1], S. Ravikanth[1], G. Vijayakumar[2]

[1]Department of Pharmacy Practice, VCOP, MGM Hosptial, Warangal, A.P, India.
[2]Department of Paediatric's, KMC/MGM Hosptial, NTR University, Warangal, A.P,India

ABSTRACT

Infectious diseases, also known as transmissible diseases or communicable diseases comprise clinically evident illness (i.e., characteristic medical signs and/or symptoms of disease) resulting from the infection, presence and growth of pathogenic biological agents in an individual host organism. In certain cases, infectious diseases may be asymptomatic for much or even their entire course in a given host. In the latter case, the disease may only be defined as a disease in hosts who secondarily become ill after contact with an asymptomatic carrier. An infection is not synonymous with an infectious disease, as some infections do not cause illness in a host. This review focused on infectious pathogens includes some viruses, bacteria, fungi, protozoa, multicellular parasites, and aberrant proteins known as prions. These pathogens are the cause of disease epidemics, in the sense that without the pathogen, no infectious epidemic occurs.

Key Words: Infectious diseases, Communicable diseases, Epidemics.

INTRODUCTION

The term infectivity describes the ability of an organism to enter, survive and multiply in the host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. Transmission of pathogen can occur in various ways including physical contact, contaminated food, body fluids, objects, airborne inhalation, or through vector organisms.

Infectious diseases are sometimes called contagious when they are easily transmitted by contact with an ill person or their secretions (e.g., influenza). Thus, a contagious disease is a subset of infectious disease that is especially infective or easily transmitted. Other types of infectious/ transmissible/communicable diseases with more specialized routes of infection, such as vector transmission or sexual transmission, are usually not regarded as contagious, and often do not require medical isolation (sometimes loosely called quarantine) of victims. However, this specialized connotation of the word contagious and contagious disease (easy transmissibility) is not always respected in popular use [1].

Classification

Among the almost infinite varieties of microorganisms, relatively few cause disease in otherwise healthy individuals. Infectious disease results from the interplay between those few pathogens and the defenses of the hosts they infect. The appearance and severity of disease resulting from any pathogen depends upon the ability of that pathogen to damage the host as well as the ability of the host to resist the pathogen. Clinicians therefore classify infectious microorganisms or microbes according to the status of host defenses - either as primary pathogens or as opportunistic pathogens:

Primary pathogens cause disease as a result of their presence or activity within the normal, healthy host, and their intrinsic virulence (the severity of the disease they cause) is, in part, a necessary consequence of their need to reproduce and spread. Many of the most common primary pathogens of humans only infect humans, however many serious diseases are caused by organisms acquired from the environment or which infect non-human hosts.

Organisms which cause an infectious disease in a host with depressed resistance are classified as opportunistic pathogens. Opportunistic disease may be caused by microbes that are ordinarily in contact with the host, such as pathogenic bacteria or fungi in the gastrointestinal or the upper respiratory tract, and they may

Corresponding Author:- **Subash Vijaya Kumar** Email: vijayvijay66@yahoo.co.in

also result from (otherwise innocuous) microbes acquired from other hosts (as in Clostridium difficile colitis) or from the environment as a result of traumatic introduction (as in surgical wound infections or compound fractures). An opportunistic disease requires impairment of host defenses, which may occur as a result of genetic defects (such as Chronic granulomatous disease), exposure to antimicrobial drugs or immunosuppressive chemicals (as might occur following poisoning or cancer chemotherapy), exposure to ionizing radiation, or as a result of an infectious disease with immunosuppressive activity (such as with measles, malaria or HIV disease). Primary pathogens may also cause more severe disease in a host with depressed resistance than would normally occur in an immunosufficient host.

One way of proving that a given disease is infectious, is to satisfy Koch's postulates (first proposed by Robert Koch), which demands that the infectious agent be identified only in patients and not in healthy controls, and that patients who contract the agent also develop the disease. These postulates were first used in the discovery that Mycobacteria species cause tuberculosis. Koch's postulates cannot be met ethically for many human diseases because they require experimental infection of a healthy individual with a pathogen produced as a pure culture. Often, even diseases that are quite clearly infectious do not meet the infectious criteria. For example, Treponema pallidum, the causative spirochete of syphilis, cannot be cultured in vitro - however the organism can be cultured in rabbit testes. It is less clear that a pure culture comes from an animal source serving as host than it is when derived from microbes derived from plate culture. Epidemiology is another important tool used to study disease in a population. For infectious diseases it helps to determine if a disease outbreak is sporadic (occasional occurrence), endemic (regular cases often occurring in a region), epidemic (an unusually high number of cases in a region), or pandemic (a global epidemic) [2].

Transmission

Washing one's hands, a form of hygiene, is the most effective way to prevent the spread of infectious disease. An infectious disease is transmitted from some source. Defining the means of transmission plays an important part in understanding the biology of an infectious agent, and in addressing the disease it causes. Transmission may occur through several different mechanisms. Respiratory diseases and meningitis are commonly acquired by contact with aerosolized droplets, spread by sneezing, coughing, talking, kissing or even singing. Gastrointestinal diseases are often acquired by ingesting contaminated food and water. Sexually transmitted diseases are acquired through contact with bodily fluids, generally as a result of sexual activity. Some infectious agents may be spread as a result of contact with a contaminated, inanimate object (known as a fomite), such as a coin passed from one person to another, while other diseases penetrate the skin directly.

Transmission of infectious diseases may also involve a vector. Vectors may be mechanical or biological. A mechanical vector picks up an infectious agent on the outside of its body and transmits it in a passive manner. An example of a mechanical vector is a housefly, which lands on cow dung, contaminating its appendages with bacteria from the feces, and then lands on food prior to consumption. The pathogen never enters the body of the fly.

In contrast, biological vectors harbor pathogens within their bodies and deliver pathogens to new hosts in an active manner, usually a bite. Biological vectors are often responsible for serious blood-borne diseases, such as malaria, viral encephalitis, Chagas disease, Lyme disease and African sleeping sickness. Biological vectors are usually, though not exclusively, arthropods, such as mosquitoes, ticks, fleas and lice. Vectors are often required in the life cycle of a pathogen. A common strategy used to control vector borne infectious diseases is to interrupt the life cycle of a pathogen by killing the vector.

The relationship between virulence and transmission is complex, and has important consequences for the long term evolution of a pathogen. Since it takes many generations for a microbe and a new host species to co-evolve, an emerging pathogen may hit its earliest victims especially hard. It is usually in the first wave of a new disease that death rates are highest. If a disease is rapidly fatal, the host may die before the microbe can get passed along to another host. However, this cost may be overwhelmed by the short term benefit of higher infectiousness if transmission is linked to virulence, as it is for instance in the case of cholera (the explosive diarrhea aids the bacterium in finding new hosts) or many respiratory infections (sneezing and coughing create infectious aerosols).

Prevention

One of the ways to prevent or slow down the transmission of infectious diseases is to recognize the different characteristics of various diseases Some critical disease characteristics that should be evaluated include virulence, distance traveled by victims, and level of contagiousness. The human strains of Ebola virus, for example, incapacitate its victims extremely quickly and kills them soon after. As a result, the victims of this disease do not have the opportunity to travel very far from the initial infection zone. Also, this virus must spread through skin lesions or permeable membranes such as the eye. Thus, the initial stage of Ebola is not very contagious since its victims experience only internal hemorrhaging. As a result of the above features, the spread of Ebola is very rapid and usually stays within a relatively confined geographical area. In contrast, the Human Immunodeficiency Virus (HIV) kills its victims very

slowly by attacking their immune system. As a result, many of its victims transmit the virus to other individuals before even realizing that they are carrying the disease. Also, the relatively low virulence allows its victims to travel long distances, increasing the likelihood of an epidemic.

Another effective way to decrease the transmission rate of infectious diseases is to recognize the effects of small-world networks. In epidemics, there are often extensive interactions within hubs or groups of infected individuals and other interactions within discrete hubs of susceptible individuals. Despite the low interaction between discrete hubs, the disease can jump to and spread in a susceptible hub via a single or few interactions with an infected hub. Thus, infection rates in small-world networks can be reduced somewhat if interactions between individuals within infected hubs are eliminated. However, infection rates can be drastically reduced if the main focus is on the prevention of transmission jumps between hubs. The use of needle exchange programs in areas with a high density of drug users with HIV is an example of the successful implementation of this treatment method. Another example is the use of ring culling or vaccination of potentially susceptible livestock in adjacent farms to prevent the spread of the foot-and-mouth virus in 2001 [3].

Immunity

Mary Mallon (a.k.a. Typhoid Mary) was an asymptomatic carrier of typhoid fever. Over the course of her career as a cook, she infected 53 people, three of whom died.

Infection with most pathogens does not result in death of the host and the offending organism is ultimately cleared after the symptoms of the disease have waned. This process requires immune mechanisms to kill or inactivate the inoculum of the pathogen. Specific acquired immunity against infectious diseases may be mediated by antibodies and/or T lymphocytes. Immunity mediated by these two factors may be manifested by:

- a direct effect upon a pathogen, such as antibody-initiated complement-dependent bacteriolysis, opsonoization, phagocytosis and killing, as occurs for some bacteria,
- neutralization of viruses so that these organisms cannot enter cells,
- or by T lymphocytes which will kill a cell parasitized by a microorganism.
- The immune system response to a microorganism often causes symptoms such as a high fever and inflammation, and has the potential to be more devastating than direct damage caused by a microbe.

Resistance to infection (immunity) may be acquired following a disease, by asymptomatic carriage of the pathogen, by harboring an organism with a similar structure (crossreacting), or by vaccination. Knowledge of the protective antigens and specific acquired host immune factors is more complete for primary pathogens than for opportunistic pathogens.

Immune resistance to an infectious disease requires a critical level of either antigen-specific antibodies and/or T cells when the host encounters the pathogen. Some individuals develop natural serum antibodies to the surface polysaccharides of some agents although they have had little or no contact with the agent, these natural antibodies confer specific protection to adults and are passively transmitted to newborns.

Host genetic factors

The clearance of the pathogens, either treatment-induced or spontaneous, it can be influenced by the genetic variants carried by the individual patients. For instance, for genotype 1 hepatitis C treated with Pegylated interferon-alpha-2a or Pegylated interferon-alpha-2b (brand names Pegasys or PEG-Intron) combined with ribavirin, it has been shown that genetic polymorphisms near the human IL28B gene, encoding interferon lambda 3, are associated with significant differences in the treatment-induced clearance of the virus. This finding, originally reported in Nature, showed that genotype 1 hepatitis C patients carrying certain genetic variant alleles near the IL28B gene are more possibly to achieve sustained virological response after the treatment than others. Later report from Nature demonstrated that the same genetic variants are also associated with the natural clearance of the genotype 1 hepatitis C virus [4].

Diagnosis

Diagnosis of infectious disease sometimes involves identifying an infectious agent either directly or indirectly. In practice most minor infectious diseases such as warts, cutaneous abscesses, respiratory system infections and diarrheal diseases are diagnosed by their clinical presentation. Conclusions about the cause of the disease are based upon the likelihood that a patient came in contact with a particular agent, the presence of a microbe in a community, and other epidemiological considerations. Given sufficient effort, all known infectious agents can be specifically identified. The benefits of identification, however, are often greatly outweighed by the cost, as often there is no specific treatment, the cause is obvious, or the outcome of an infection is benign.

Diagnosis of infectious disease is nearly always initiated by medical history and physical examination. More detailed identification techniques involve the culture of infectious agents isolated from a patient. Culture allows identification of infectious organisms by examining their microscopic features, by detecting the presence of substances produced by pathogens, and by directly identifying an organism by its genotype. Other techniques (such as X-rays, CAT scans, PET scans or NMR) are used to produce images of internal abnormalities resulting from

the growth of an infectious agent. The images are useful in detection of, for example, a bone abscess or a spongiform encephalopathy produced by a prion.

Microbial culture

Microbiological culture is a principal tool used to diagnose infectious disease. In a microbial culture, a growth medium is provided for a specific agent. A sample taken from potentially diseased tissue or fluid is then tested for the presence of an infectious agent able to grow within that medium. Most pathogenic bacteria are easily grown on nutrient agar, a form of solid medium that supplies carbohydrates and proteins necessary for growth of a bacterium, along with copious amounts of water. A single bacterium will grow into a visible mound on the surface of the plate called a colony, which may be separated from other colonies or melded together into a lawn. The size, color, shape and form of a colony is characteristic of the bacterial species, its specific genetic makeup (its strain), and the environment which supports its growth. Other ingredients are often added to the plate to aid in identification. Plates may contain substances that permit the growth of some bacteria and not others, or that change color in response to certain bacteria and not others. Bacteriological plates such as these are commonly used in the clinical identification of infectious bacterium. Microbial culture may also be used in the identification of viruses: the medium in this case being cells grown in culture that the virus can infect, and then alter or kill. In the case of viral identification, a region of dead cells results from viral growth, and is called a plaque. Eukaryotic parasites may also be grown in culture as a means of identifying a particular agent.

In the absence of suitable plate culture techniques, some microbes require culture within live animals. Bacteria such as Mycobacterium leprae and T. pallidum can be grown in animals, although serological and microscopic techniques make the use of live animals unnecessary. Viruses are also usually identified using alternatives to growth in culture or animals. Some viruses may be grown in embryonated eggs. Another useful identification method is Xenodiagnosis, or the use of a vector to support the growth of an infectious agent. Chagas disease is the most significant example, because it is difficult to directly demonstrate the presence of the causative agent, Trypanosoma cruzi in a patient, which therefore makes it difficult to definitively make a diagnosis. In this case, xenodiagnosis involves the use of the vector of the Chagas agent T. cruzi, an uninfected triatomine bug, which takes a blood meal from a person suspected of having been infected. The bug is later inspected for growth of T. cruzi within its gut.

Microscopy

Another principal tool in the diagnosis of infectious disease is microscopy. Virtually all of the culture techniques discussed above rely, at some point, on microscopic examination for definitive identification of the infectious agent. Microscopy may be carried out with simple instruments, such as the compound light microscope, or with instruments as complex as an electron microscope. Samples obtained from patients may be viewed directly under the light microscope, and can often rapidly lead to identification. Microscopy is often also used in conjunction with biochemical staining techniques, and can be made exquisitely specific when used in combination with antibody based techniques. For example, the use of antibodies made artificially fluorescent (fluorescently labeled antibodies) can be directed to bind to and identify a specific antigens present on a pathogen. A fluorescence microscope is then used to detect fluorescently labeled antibodies bound to internalized antigens within clinical samples or cultured cells. This technique is especially useful in the diagnosis of viral diseases, where the light microscope is incapable of identifying a virus directly.

Other microscopic procedures may also aid in identifying infectious agents. Almost all cells readily stain with a number of basic dyes due to the electrostatic attraction between negatively charged cellular molecules and the positive charge on the dye. A cell is normally transparent under a microscope, and using a stain increases the contrast of a cell with its background. Staining a cell with a dye such as Giemsa stain or crystal violet allows a microscopist to describe its size, shape, internal and external components and its associations with other cells. The response of bacteria to different staining procedures is used in the taxonomic classification of microbes as well. Two methods, the Gram stain and the acid-fast stain, are the standard approaches used to classify bacteria and to diagnosis of disease. The Gram stain identifies the bacterial groups Firmicutes and Actinobacteria, both of which contain many significant human pathogens. The acid-fast staining procedure identifies the Actinobacterial genera Mycobacterium and Nocardia [5].

Biochemical tests

Biochemical tests used in the identification of infectious agents include the detection of metabolic or enzymatic products characteristic of a particular infectious agent. Since bacteria ferment carbohydrates in patterns characteristic of their genus and species, the detection of fermentation products is commonly used in bacterial identification. Acids, alcohols and gases are usually detected in these tests when bacteria are grown in selective liquid or solid media.

The isolation of enzymes from infected tissue can also provide the basis of a biochemical diagnosis of an infectious disease. For example, humans can make neither RNA replicases nor reverse transcriptase, and the presences of these enzymes are characteristic of specific types of viral infections. The ability of the viral protein

hemagglutinin to bind red blood cells together into a detectable matrix may also be characterized as a biochemical test for viral infection, although strictly speaking hemagglutinin is not an enzyme and has no metabolic function.

Serological methods are highly sensitive, specific and often extremely rapid tests used to identify microorganisms. These tests are based upon the ability of an antibody to bind specifically to an antigen. The antigen, usually a protein or carbohydrate made by an infectious agent, is bound by the antibody. This binding then sets off a chain of events that can be visibly obvious in various ways, dependent upon the test. For example, Strep throat is often diagnosed within minutes, and is based on the appearance of antigens made by the causative agent, S. pyogenes, that is retrieved from a patients throat with a cotton swab. Serological tests, if available, are usually the preferred route of identification, however the tests are costly to develop and the reagents used in the test often require refrigeration. Some serological methods are extremely costly, although when commonly used, such as with the strep test, they can be inexpensive.

Complex serological techniques have been developed into what are known as Immunoassays. Immunoassays can use the basic antibody – antigen binding as the basis to produce an electro - magnetic or particle radiation signal, which can be detected by some form of instrumentation. Signal of unknowns can be compared to that of standards allowing quantitation of the target antigen. To aid in the diagnosis of infectious diseases, immunoassays can detect or measure antigens from either infectious agents or proteins generated by an infected organism in response to a foreign agent. For example, immunoassay A may detect the presence of a surface protein from a virus particle. Immunoassay B on the other hand may detect or measure antibodies produced by an organism's immune system which are made to neutralize and allow the destruction of the virus.

Instrumentation can be used to read extremely small signals created by secondary reactions linked to the antibody – antigen binding. Instrumentation can control sampling, reagent use, reaction times, signal detection, calculation of results, and data management to yield a cost effective automated process for diagnosis of infectious disease [6].

Molecular diagnostics

Technologies based upon the polymerase chain reaction (PCR) method will become nearly ubiquitous gold standards of diagnostics of the near future, for several reasons. First, the catalog of infectious agents has grown to the point that virtually all of the significant infectious agents of the human population have been identified. Second, an infectious agent must grow within the human body to cause disease; essentially it must amplify its own nucleic acids in order to cause a disease. This amplification of nucleic acid in infected tissue offers an opportunity to detect the infectious agent by using PCR. Third, the essential tools for directing PCR, primers, are derived from the genomes of infectious agents, and with time those genomes will be known, if they are not already.

Thus, the technological ability to detect any infectious agent rapidly and specifically are currently available. The only remaining blockades to the use of PCR as a standard tool of diagnosis are in its cost and application, neither of which is insurmountable. The diagnosis of a few diseases will not benefit from the development of PCR methods, such as some of the clostridial diseases (tetanus and botulism). These diseases are fundamentally biological poisonings by relatively small numbers of infectious bacteria that produce extremely potent neurotoxins. A significant proliferation of the infectious agent does not occur, this limits the ability of PCR to detect the presence of any bacteria.

Indication of tests

There is usually an indication for a specific identification of an infectious agent only when such identification can aid in the treatment or prevention of the disease, or to advance knowledge of the course of an illness prior to the development of effective therapeutic or preventative measures. For example, in the early 1980s, prior to the appearance of AZT for the treatment of AIDS, the course of the disease was closely followed by monitoring the composition of patient blood samples, even though the outcome would not offer the patient any further treatment options. In part, these studies on the appearance of HIV in specific communities permitted the advancement of hypotheses as to the route of transmission of the virus. By understanding how the disease was transmitted, resources could be targeted to the communities at greatest risk in campaigns aimed at reducing the number of new infections. The specific serological diagnostic identification, and later genotypic or molecular identification, of HIV also enabled the development of hypotheses as to the temporal and geographical origins of the virus, as well as a myriad of other hypothesis. The development of molecular diagnostic tools have enabled physicians and researchers to monitor the efficacy of treatment with anti-retroviral drugs. Molecular diagnostics are now commonly used to identify HIV in healthy people long before the onset of illness and have been used to demonstrate the existence of people who are genetically resistant to HIV infection. Thus, while there still is no cure for AIDS, there is great therapeutic and predictive benefit to identifying the virus and monitoring the virus levels within the blood of infected individuals, both for the patient and for the community at large [7].

Historic pandemics

A young Bangladeshi girl infected with smallpox (1973). Due to the development of the smallpox vaccine,

the disease was officially eradicated in 1979. A pandemic (or global epidemic) is a disease that affects people over an extensive geographical area. Plague of Justinian, from 541 to 750, killed between 50% and 60% of Europe's population.

The Black Death of 1347 to 1352 killed 25 million in Europe over 5 years (estimated to be between 25 and 50% of the populations of Europe, Asia, and Africa - the world population at the time was 500 million). The introduction of smallpox, measles, and typhus to the areas of Central and South America by European explorers during the 15th and 16th centuries caused pandemics among the native inhabitants. Between 1518 and 1568 disease pandemics are said to have caused the population of Mexico to fall from 20 million to 3 million.

The first European influenza epidemic occurred between 1556 and 1560, with an estimated mortality rate of 20%. Smallpox killed an estimated 60 million Europeans during the 18th century (approximately 400,000 per year). Up to 30% of those infected, including 80% of the children under 5 years of age, died from the disease, and one-third of the survivors went blind.

In the 19th century, tuberculosis killed an estimated one-quarter of the adult population of Europe; by 1918 one in six deaths in France were still caused by TB. The Influenza Pandemic of 1918 (or the Spanish Flu) killed 25-50 million people (about 2% of world population of 1.7 billion). Today Influenza kills about 250,000 to 500,000 worldwide each year.

Emerging diseases

In most cases, microorganisms live in harmony with their hosts via mutual or commensal interactions. Diseases can emerge when existing parasites become pathogenic or when new pathogenic parasites enter a new host.

Coevolution between parasite and host can lead to hosts becoming resistant to the parasites or the parasites may evolve greater virulence, leading to immunopathological disease. Human activity is involved with many emerging infectious diseases, such as environmental change enabling a parasite to occupy new niches. When that happens, a pathogen that had been confined to a remote habitat has a wider distribution and possibly a new host organism. Parasites jumping from nonhuman to human hosts are known as zoonoses. Under disease invasion, when a parasite invades a new host species, it may become pathogenic in the new host.

***Encroachment on wildlife habitats*.** The construction of new villages and housing developments in rural areas force animals to live in dense populations, creating opportunities for microbes to mutate and emerge.

Changes in agriculture. The introduction of new crops attracts new crop pests and the microbes they carry to farming communities, exposing people to unfamiliar diseases.

The destruction of rain forests. As countries make use of their rain forests, by building roads through forests and clearing areas for settlement or commercial ventures, people encounter insects and other animals harboring previously unknown microorganisms.

Uncontrolled urbanization. The rapid growth of cities in many developing countries tends to concentrate large numbers of people into crowded areas with poor sanitation. These conditions foster transmission of contagious diseases.

Modern transport. Ships and other cargo carriers often harbor unintended passengers, that can spread diseases to faraway destinations. While with international jet-airplane travel, people infected with a disease can carry it to distant lands, or home to their families, before their first symptoms appear [8].

Medical specialists

The medical treatment of infectious diseases falls into the medical field of Infectiology and in some cases the study of propagation pertains to the field of Epidemiology. Generally, infections are initially diagnosed by primary care physicians or internal medicine specialists. For example, an uncomplicated pneumonia will generally be treated by the internist or the pulmonologist (lung physician).The work of the infectiologist therefore entails working with both patients and general practitioners, as well as laboratory scientists, immunologists, bacteriologists and other specialists.

An infectious disease team may be alerted when:

- The disease has not been definitively diagnosed after an initial workup
- The patient is immunocompromised (for example, in AIDS or after chemotherapy);
- The infectious agent is of an uncommon nature (e.g. tropical diseases);
- The disease has not responded to first line antibiotics;
- The disease might be dangerous to other patients, and the patient might have to be isolated

Infection control

Infection control is the discipline concerned with preventing nosocomial or healthcare-associated infection, a practical (rather than academic) sub-discipline of epidemiology. It is an essential, though often underrecognized and undersupported, part of the infrastructure of health care. Infection control and hospital epidemiology are akin to public health practice, practiced within the confines of a particular health-care delivery system rather than directed at society as a whole.

Infection control addresses factors related to the spread of infections within the health-care setting (whether patient-to-patient, from patients to staff and from staff to patients, or among-staff), including prevention (via hand hygiene/hand washing, cleaning/disinfection/sterilization, vaccination, surveillance), monitoring/investigation of demonstrated or suspected spread of infection within a particular health-care setting (surveillance and outbreak investigation), and management (interruption of outbreaks). It is on this basis that the common title being adopted within health care is Infection Prevention & Control.

Infection control in healthcare facilities

Aseptic technique is a key component of all invasive medical procedures. Similarly, infection control measures are most effective when Standard Precautions (health care) are applied because undiagnosed infection is common.

Hand hygiene

Independent studies by Ignaz Semmelweis in 1847 in Vienna and Oliver Wendell Holmes in 1843 in Boston established a link between the hands of health care workers and the spread of hospital-acquired disease. The Centers for Disease Control and Prevention (CDC) has stated that It is well documented that the most important measure for preventing the spread of pathogens is effective handwashing. In the United States, hand washing is mandatory in most health care settings and required by many different state and local regulations.

In the United States, Occupational Safety and Health Administration (OSHA) standards require that employers must provide readily accessible hand washing facilities, and must ensure that employees wash hands and any other skin with soap and water or flush mucous membranes with water as soon as feasible after contact with blood or other potentially infectious materials (OPIM).

Drying is an essential part of the hand hygiene process. The study was presented to the European Tissue Symposium by the University of Westminster, London, comparing the bacteria levels present after the use of paper towels, warm air hand dryers, and modern jet-air hand dryers. Of those three methods, only paper towels reduced the total number of bacteria on hands, with through-air dried towels the most effective.

The presenters also carried out tests to establish whether there was the potential for cross-contamination of other washroom users and the washroom environment as a result of each type of drying method. They found that:

- the jet air dryer, which blows air out of the unit at claimed speeds of 400 mph, was capable of blowing micro-organisms from the hands and the unit and potentially contaminating other washroom users and the washroom environment up to 2 metres away
- use of a warm air hand dryer spread micro-organisms up to 0.25 metres from the dryer
- paper towels showed no significant spread of micro-organisms.

In 2005, in a study conducted by TUV Produkt und Umwelt, different hand drying methods were evaluated. Sterilization is a process intended to kill all microorganisms and is the highest level of microbial kill that is possible. Sterilizers may be heat only, steam, or liquid chemical. Effectivness of the sterilizer (e.g., a steam autoclave) is determined in three ways. First, mechanical indicators and gauges on the machine itself indicate proper operation of the machine. Second heat sensitive indicators or tape on the sterilizing bags change color which indicate proper levels of heat or steam. And, third (most importantly) is biological testing in which a highly heat and chemical resistant microorganism (often the bacterial endospore) is selected as the standard challenge. If the process kills this microorganism, the sterilizer is considered to be effective. It should be noted that in order to be effective, instruments must be cleaned, otherwise the debris may form a protective barrier, shielding the microbes from the lethal process. Similarly care must be taken after sterilization to ensure sterile instruments do not become contaminated prior to use.

Disinfection refers to the use of liquid chemicals on surfaces and at room temperature to kill disease causing microorganisms. Disinfection is a less effective process than sterilization because it does not kill bacterial endospores.

Sterilization, if performed properly, is an effective way of preventing bacteria from spreading. It should be used for the cleaning of the medical instruments or gloves, and basically any type of medical item that comes into contact with the blood stream and sterile tissues.

There are four main ways in which such items can be sterilized: autoclave (by using high-pressure steam), dry heat (in an oven), by using chemical sterilants such as glutaraldehydes or formaldehyde solutions or by radiation (with the help of physical agents). The first two are the most used methods of sterilizations mainly because of their accessibility and availability. Steam sterilization is one of the most effective types of sterilizations, if done correctly which is often hard to achieve. Instruments that are used in health care facilities are usually sterilized with this method. The general rule in this case is that in order to perform an effective sterilization, the steam must get into contact with all the surfaces that are meant to be disinfected. On the other hand, dry heat sterilization, which is performed with the help of an oven, is also an accessible type of sterilization, although it can only be used to disinfect instruments that are made of metal or glass. The very high temperatures needed to perform sterilization in this way are able to melt the instruments that are not made of glass or metal.

Steam sterilization is done at a temperature of 121 C (250 F) with a pressure of 106 kPa (15 lbs/in2). In these conditions, unwrapped items must be sterilized for 20 minutes, and wrapped items for 30 minutes. The time is counted once the temperature that is needed has been reached. Steam sterilization requires four conditions in order to be efficient: adequate contact, sufficiently high temperature, correct time and sufficient moisture. Sterilization using steam can also be done at a temperature of 132 C (270 F), at a double pressure. Dry heat sterilization is performed at 170 C (340 F) for one hour or two hours at a temperature of 160 C (320 F). Dry heat sterilization can also be performed at 121 C, for at least 16 hours.

Chemical sterilization, also referred to as cold sterilization, can be used to sterilize instruments that cannot normally be disinfected through the other two processes described above. The items sterilized with cold sterilization are usually those that can be damaged by regular sterilization. Commonly, glutaraldehydes and formaldehyde are used in this process, but in different ways. When using the first type of disinfectant, the instruments are soaked in a 2-4% solution for at least 10 hours while a solution of 8% formaldehyde will sterilize the items in 24 hours or more. Chemical sterilization is generally more expensive than steam sterilization and therefore it is used for instruments that cannot be disinfected otherwise. After the instruments have been soaked in the chemical solutions, they are mandatory to be rinsed with sterile water which will remove the residues from the disinfectants. This is the reason why needles and syringes are not sterilized in this way, as the residues left by the chemical solution that has been used to disinfect them cannot be washed off with water and they may interfere with the administered treatment. Although formaldehyde is less expensive than glutaraldehydes, it is also more irritating to the eyes, skin and respiratory tract and is classified as a potential carcinogen.

Other sterilization methods exist, though their efficiency is still controversial. These methods include gas sterilization, UV sterilization, and sterilization with other chemical agents such as peroxyacetic acid, paraformaldehyde and gas plasma sterilization.

Infections can be prevented from occurring in homes as well. In order to reduce their chances to contract an infection, individuals are recommended to maintain a good hygiene by washing their hands after every contact with questionable areas or bodily fluids and by disposing the garbage at regular intervals to prevent germs from growing.

Personal protective equipment

Personal protective equipment (PPE) is specialized clothing or equipment worn by a worker for protection against a hazard. The hazard in a health care setting is exposure to blood, saliva, or other bodily fluids or aerosols that may carry infectious materials such as Hepatitis C, HIV, or other blood borne or bodily fluid pathogen. PPE prevents contact with a potentially infectious material by creating a physical barrier between the potential infectious material and the healthcare worker. In the United States, the Occupational Safety and Health Administration (OSHA) requires the use of Personal protective equipment (PPE) by workers to guard against blood borne pathogens if there is a reasonably anticipated exposure to blood or other potentially infectious materials.

Components of Personal protective equipment (PPE) include gloves, gowns, bonnets, shoe covers, face shields, CPR masks, goggles, surgical masks, and respirators. How many components are used and how the components are used is often determined by regulations or the infection control protocol of the facility in question. Many or most of these items are disposable to avoid carrying infectious materials from one patient to another patient and to avoid difficult or costly disinfection. In the United States, OSHA requires the immediate removal and disinfection or disposal of worker's PPE prior to leaving the work area where exposure to infectious material took place [10].

Antimicrobial surfaces

Microorganisms are known to survive on non-antimicrobial inanimate ‘touch’ surfaces (e.g., bedrails, over-the-bed trays, call buttons, bathroom hardware, etc.) for extended periods of time. This can be especially troublesome in hospital environments where patients with immunodeficiencies are at enhanced risk for contracting nosocomial infections.

Products made with antimicrobial copper alloy (brasses, bronzes, cupronickel, copper-nickel-zinc, and others) surfaces destroy a wide range of microorganisms in a short period of time. The United States Environmental Protection Agency has approved the registration of 355 different antimicrobial copper alloys that kill E. coli O157:H7, methicillin-resistant Staphylococcus aureus (MRSA), Staphylococcus, Enterobacter aerogenes, and Pseudomonas aeruginosa in less than 2 hours of contact. Other investigations have demonstrated the efficacy of antimicrobial copper alloys to destroy Clostridium difficile, influenza A virus, adenovirus, and fungi. As a public hygienic measure in addition to regular cleaning, antimicrobial copper alloys are being installed in healthcare facilities in the U.K., Ireland, Japan, Korea, France, Denmark, and Brazil.

Vaccination of health care workers

Health care workers may be exposed to certain infections in the course of their work. Vaccines are available to provide some protection to workers in a healthcare setting. Depending on regulation, recommendation, the specific work function, or personal preference, healthcare workers or first responders may

receive vaccinations for hepatitis B; influenza; measles, mumps and rubella; Tetanus, diphtheria, pertussis; N. meningitidis; and varicella. In general, vaccines do not guarantee complete protection from disease, and there is potential for adverse effects from receiving the vaccine.

Post exposure prophylaxis

In some cases where vaccines do not exist Post Exposure prophylaxis is another method of protecting the health care worker exposed to a life threatening infectious disease. For example, the viral particles for HIV-AIDS can be precipitated out of the blood through the use of an antibody injection if given within 4 hours of a significant exposure.

Surveillance for emerging infections

Surveillance is the act of infection investigation using the CDC definitions. Determining an infection requires an Infection Control Practitioner (ICP) to review a patient's chart and see if the patient had the signs and symptom of an infection. Surveillance definitions cover infections of the bloodstream, urinary tract, pneumonia, and surgical sites.

Surveillance traditionally involved significant manual data assessment and entry in order to assess preventative actions such as isolation of patients with an infectious disease. Increasingly, integrated computerized software solutions, such as Formic Fusion are becoming available that assess incoming risk messages from microbiology and other online sources. By reducing the need for data entry, this software significantly reduces the data workload of ICPs, freeing them to concentrate on clinical surveillance.

As approximately one third of healthcare acquired infections are preventable, surveillance and preventative activities are increasingly a priority for hospital staff. In the United States, a study on the Efficacy of Nosocomial Infection Control Project (SENIC) by the CDC found that hospitals reduced their nosocomial infection rates by approximately 32 per cent by focusing on surveillance activities and prevention efforts.

Isolation

In the health care context, isolation refers to various physical measures taken to interrupt nosocomial spread of contagious diseases. Various forms of isolation exist, and are applied depending on the type of infection and agent involved, to address the likelihood of spread via airborne particles or droplets, by direct skin contact, or via contact with body fluid

Outbreak investigation

When an unusual cluster of illness is noted, infection control teams undertake an investigation to determine whether there is a true outbreak, a pseudo-outbreak (a result of contamination within the diagnostic testing process), or just random fluctuation in the frequency of illness. If a true outbreak is discovered, infection control practitioners try to determine what permitted the outbreak to occur, and to rearrange the conditions to prevent ongoing propagation of the infection. Often, breaches in good practice are responsible, although sometimes other factors (such as construction) may be the source of the problem.

Outbreaks investigations have more than a single purpose. These investigations are carried out in order to prevent additional cases in the current outbreak, prevent future outbreaks, learn about a new disease or learn something new about an old disease. Reassuring the public, minimizing the economic and social disruption as well as teaching epidemiology are some other obvious objectives of outbreak investigations.

According to the WHO, outbreak investigations are meant to detect what is causing the outbreak, how the pathogenic agent is transmitted, where it all started from, what is the carrier, what is the population at risk of getting infected and what are the risk factors. The results of outbreak investigations are always made public in the means of a report in which the findings are communicated to the authorities, media, scientific community and so on. These reports are commonly used as pedagogical tools.

Training in infection control and health care epidemiology

Practitioners can come from several different educational streams. Many begin as nurses, some as medical technologists (particularly in clinical microbiology), and some as physicians (typically infectious disease specialists). Specialized training in infection control and health care epidemiology are offered by the professional organizations described below. Physicians who desire to become infection control practitioners often are trained in the context of an infectious disease fellowship.

In the United States, Certification Board of Infection Control and Epidemiology is a private company that certifies infection control practitioners based on their educational background and professional experience, in conjunction with testing their knowledge base with standardized exams. The credential awarded is CIC, Certification in Infection Control and Epidemiology. It is recommended that one has 2 years of Infection Control experience before applying for the exam. Certification must be renewed every five years.

A course in hospital epidemiology (infection control in the hospital setting) is offered jointly each year by the Centers for Disease Control and Prevention (CDC) and the Society for Healthcare Epidemiology of America. The Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) offers training and courses in infection control.

Eradication of infectious diseases

Eradication is the reduction of an infectious disease's prevalence in the global host population to zero. It is sometimes confused with elimination, which describes either the reduction of an infectious disease's prevalence in a regional population to zero, or the reduction of the global prevalence to a negligible amount. Further confusion arises from the use of the term eradication to refer to the total removal of a given pathogen from an individual (also known as clearance of an infection), particularly in the context of HIV and certain other viruses where such cures are sought.

Eight attempts have been made to date to eradicate infectious diseases—four aborted programs targeting hookworm, malaria, yaws, and yellow fever, two successful programs targeting smallpox and rinderpest, and two ongoing programs targeting poliomyelitis and dracunculiasis. Five more infectious diseases have been identified as of April 2008 as potentially eradicable with current technology by the Carter Center International Task Force for Disease Eradication—measles, mumps, rubella, lymphatic filariasis and cysticercosis.

Eradicated

So far, two diseases have been successfully eradicated—one specifically affecting humans (smallpox), and one affecting a wide range of ruminants (rinderpest).

Smallpox

Smallpox is the first disease, and so far the only infectious disease of humans, to have been eradicated by human undertakings. It became the first disease for which there was an effective vaccination when Edward Jenner demonstrated in 1798 that inoculation of humans with cowpox could protect against smallpox.

The virus causing smallpox, Variola vera, has two variants: variola major, with a mortality rate around 30 percent, and variola minor, with a mortality rate less than 1 percent. The last naturally occurring case of variola major was diagnosed in October 1975 in Bangladesh, and the last naturally occurring case of variola minor was diagnosed in October 1977 in Somalia. The global eradication of smallpox was certified by a commission of scientists on December 9, 1979 and endorsed by the World Health Assembly on May 8, 1980.

Rinderpest

During the 20th century, there were a series of campaigns to eradicate rinderpest, a viral disease which infected cattle and other ruminants and belonged to the same family as measles, primarily through the use of a live attenuated vaccine. The final, successful campaign was led by the Food and Agriculture Organization (FAO) of the United Nations. On 14 October 2010, with no diagnoses for nine years, the FAO announced that the disease had been completely eradicated, making this the first (and so far the only) disease of livestock to have been eradicated by human undertakings.

Global eradication underway

A dramatic reduction of the incidence of poliomyelitis in industrialized countries followed the development of a vaccine in the 1950s. In 1960, Czechoslovakia became the first country certified to have eliminated polio. In 1988, the World Health Organization (WHO), Rotary International, the United Nations Children's Fund (UNICEF), and the U.S. Centers for Disease Control and Prevention (CDC) passed the Global Polio Eradication Initiative. Its goal was to eradicate polio by the year 2000. The updated strategic plan for 2004–2008 expects to achieve global eradication by interrupting poliovirus transmission, using the strategies of routine immunization, supplementary immunization campaigns, and surveillance of possible outbreaks. The WHO estimates that global savings from eradication, due to forgone treatment and disability costs, could exceed one billion U.S. dollars per year.

The following world regions have been declared polio-free:

- The Americas (1994)
- Indo-West Pacific region (1997)
- Europe (1998)
- Western Pacific region, including China (2000)

The lowest annual polio prevalence seen so far was in 2001, with 483 reported cases. However, following interruption of vaccination in Nigeria in 2003–4 and a reduction in immunisation in India in 2001–2, there was a resurgence of polio transmission: in the period of 2002 to 2009, the number of global reported cases has remained between 750 and 2000 per year, with 1,606 cases in 2009. Some of these cases were the result of new importations in 31 countries which had previously interrupted transmission, leading to many subsequent outbreaks; 19 of these countries reported cases in 2009. Three further countries remain in which poliovirus transmission has never been interrupted (Nigeria, Pakistan, and Afghanistan) India was removed from the WHO list of polio-endemic countries in 2012 after no new cases were reported for one year. The current provisional total for 2011 stands at 650 cases from 16 countries. The six months to the end of March 2012 saw the lowest case count ever reported for that period for the past ten years. As of 22nd May 2012, 60 cases from 4 countries have been reported (35 from Nigeria; 16 in Pakistan; 6 in Afghanistan and 3 in Chad), compared to 166 cases from 12 countries for the same period last year.

Dracunculiasis, also called guinea worm disease, is a painful and disabling parasitic disease caused by a worm, Dracunculus medinensis. It is spread through consumption of drinking water infested with copepods hosting Dracunculus larvae. The Carter Center has led the

effort to eradicate the disease, along with the CDC, the WHO, UNICEF, and the Bill and Melinda Gates Foundation.

Unlike diseases such as smallpox and polio, there is no vaccine nor drug therapy for guinea worm. Eradication efforts have been based on making drinking water supplies safer (e.g. by provision of borehole wells, or through treating the water with larvicide), on containment of infection and on education for safe drinking water practices. These strategies have produced many successes: two decades of eradication efforts have reduced guinea worm's global incidence to 1,060 cases in 2011, down from an estimated 3.5 million in 1986. Success has been slower than was hoped—the original goal for eradication was 1995. The WHO has certified 180 countries free of the disease, and only four countries—South Sudan, Mali, Ethiopia and Chad — reported cases of guinea worm in 2011. 97% of all cases reported in 2011 were in South Sudan. As of 2010, the WHO predicted it would be a few years yet before eradication is achieved, on the basis that it took 6–12 years for the countries that have so far eliminated guinea worm transmission to do so after reporting a similar number of cases to that reported by Sudan in 2009.

Regional elimination established or under way

Some diseases have already been eliminated from large regions of the world, and/or are currently being targeted for regional elimination. This is sometimes described as eradication, although technically the term only applies when this is achieved on a global scale. Even after regional elimination is successful, interventions often need to continue to prevent a disease becoming re-established. Three of the diseases here listed (lymphatic filariasis, measles, and rubella) are among the diseases believed to be potentially eradicable by the International Task Force for Disease Eradication, and if successful, regional elimination programs may yet prove a stepping stone to later global eradication programs.

This section does not cover elimination where it is used to mean control programs sufficiently tight to reduce the burden of an infectious disease or other health problem to a level where they may be deemed to have little impact on public health, such as the leprosy, neonatal tetanus, or obstetric fistula campaigns [10].

Malaria

Malaria elimination has already been achieved in most of Europe, North America, Australasia, North Africa and the Caribbean, and parts of South America, Asia and Southern Africa, according to the Malaria Elimination Group at UCSF. The WHO defines elimination as having no domestic transmission for the past three years. They also define an elimination stage when a country is on the verge of eliminating malaria, as being <1 case per 1000 people at risk per year. According to the 2011 WHO World Malaria Report, 28 countries are certified as having eliminated malaria. Eight countries appear to be malaria free but steps still need to be taken to ensure they do not re-establish transmission. Nine countries are in the elimination stage and eight the pre-elimination stage (<5 cases per 1000 people at risk per year). The WHO also reports in 2010 malaria killed approximately 655,000 people. That is down about 36,000 from 2009.

There has also been a discussion of moving to global eradication. At the Gates Foundation Malaria Forum in October 2007, Bill and Melinda Gates called for a new plan for malaria eradication, by going as far as possible with existing tools while also investing in new ones. Nearly a year later, on September 25, 2008, the Roll Back Malaria (RBM) Partnership unveiled the Global Malaria Action Plan (GMAP), in which a series of measures were proposed to eliminate malaria as a global public health concern by 2015, eliminate all malaria transmission within 8–10 countries by the same deadline, and build towards its eventual global eradication.

Lymphatic filariasis

Lymphatic filariasis is an infection of the lymph system by mosquito-borne microfilarial worms which can cause elephantiasis. Studies have demonstrated that transmission of the infection can be broken when a single dose of combined oral medicines is consistently maintained annually for approximately seven years. The strategy for eliminating transmission of lymphatic filariasis is mass distribution of medicines that kill the microfilariae and stop transmission of the parasite by mosquitoes in endemic communities. In sub-Saharan Africa, albendazole (donated by GlaxoSmithKline) is being used with ivermectin (donated by Merck & Co.) to treat the disease, whereas elsewhere in the world albendazole is used with diethylcarbamazine. Using a combination of treatments better reduces the number of microfilariae in blood. Avoiding mosquito bites, such as by using insecticide-treated mosquito bed nets, also reduces the transmission of lymphatic filariasis. In the Americas, >90% of the burden of lymphatic filariasis is on the island of Hispaniola (comprising Haiti and the Dominican Republic). An elimination effort to address this is currently under way alongside the malaria effort described above; the Dominican Republic expects to eliminate its seven remaining foci by 2010, but lymphatic filariasis is still endemic to 110 of 140 communes in Haiti.

As of October 2008, the efforts of the Global Programme to Eliminate LF are estimated to have already prevented 6.6 million new filariasis cases from developing in children, and to have stopped the progression of the disease in another 9.5 million people who have already contracted it. Overall, of 83 endemic countries, mass treatment has been rolled out in 48, and elimination of transmission reportedly achieved in 21.

Measles

Five out of six WHO regions have goals to eliminate measles, and at the 63rd World Health Assembly in May 2010, delegates agreed to move towards eventual eradication, although no specific global target date has yet been agreed. The Americas set a goal in 1994 to eliminate measles and rubella transmission by 2000, and successfully achieved regional measles elimination in 2002, although there have been occasional small outbreaks from imported cases since then. Europe had set a goal to eliminate measles transmission by 2010, but were hindered by the MMR vaccine controversy and by low uptake in certain groups, and despite achieving low levels by 2008, European countries have since experienced a small resurgence in cases. The Eastern Mediterranean also had goals to eliminate measles by 2010, The Western Pacific aims to eliminate the disease by 2012, and in 2009 the regional committee for Africa agreed a goal of measles elimination by 2020. As of May 2010, only the South-East Asian region has yet to set a target date for elimination of measles transmission.

In 2005, a global target was agreed for a 90% reduction in measles deaths by 2010 from the 757,000 deaths in 2000; estimates for 2008 show a 78% decline so far to 164,000 deaths. However, some have been pushing to attempt global eradication. This was updated at the 2010 world health assembly to a targeted 95% reduction in mortality by 2015, alongside specific vaccination and structural targets, and in a meeting in November 2010, the Strategic Advisory Group of Experts on Immunization concluded that measles can and should be eradicated. A study of the costs of eradicating measles compared to the costs of maintaining indefinite control was commissioned in 2009 by the WHO and the Bill and Melinda Gates Foundation [8-10].

Rubella

Two WHO regions have set 2010 as a target for rubella elimination. The WHO region of the Americas set itself a target for regional elimination of rubella and congenital rubella syndrome by 2010. As of 2010, the last confirmed endemic case of rubella in the Americas was in Argentina in February 2009 and verification of regional elimination is currently under way and due to complete by 2012. The WHO European region also set a target of 2010. However, as of 2008 there were still 20,579 reported cases of rubella, 311 of which were laboratory confirmed, just among the 27 countries reporting data to EUVAC.

Onchocerciasis

Onchocerciasis (river blindness) is the world's second leading cause of infectious blindness. It is caused by the nematode Onchocerca volvulus, which is transmitted to people via the bite of a black fly. Elimination of this disease is under way in the region of the Americas, where this disease is endemic to Brazil, Colombia, Ecuador, Guatemala, Mexico and Venezuela. The principal tool being used is mass ivermectin treatment. If successful, the only remaining endemic locations would be in Africa and Yemen. In Africa, it is estimated that greater than 102 million people in 19 countries are at high risk of onchocerciasis infection, and in 2008, 56.7 million people in 15 of these countries received community-directed treatment with ivermectin. Since adopting such treatment measures in 1997, the African Programme for Onchocerciasis Control reports a reduction in the prevalence of onchocerciasis in the countries under its mandate from a pre-intervention level of 46.5% in 1995 to 28.5% in 2008. Some African countries, such as Uganda, are also attempting elimination and successful elimination was reported in 2009 from two endemic foci in Mali and Senegal.

Yaws

Yaws is a rarely fatal but highly disfiguring disease caused by the spiral-shaped bacterium (spirochete) Treponema pertenue, a relative of the syphilis bacteria Treponema pallidum, spread through skin to skin contact with infectious lesions. The global prevalence of this disease and the other endemic trematoses, Bejel and Pinta, was reduced by the Global Control of Treponematoses (TCP) programme between 1952 and 1964 from about 50 million cases to about 2.5 million (a 95% reduction). However, following the cessation of this program these diseases remained at a low prevalence in parts of Asia, Africa and the Americas with sporadic outbreaks. Yaws is currently targeted by the South-East Asian Regional Office of the WHO for elimination from the remaining endemic countries in this region (India, Indonesia and East Timor) by 2010, and so far, this appears to have met with some success, since no cases have been seen in India since 2004 [10].

CONCLUSION

A number of studies have reported associations between pathogen load in an area and human behavior. Higher pathogen load is associated with decreased size of ethnic and religious groups in an area. This may be due high pathogen load favoring avoidance other groups which may reduce pathogen transmission or a high pathogen load preventing the creation of large settlements and armies which enforce a common culture. Higher pathogen load is also associated with more restricted sexual behavior which may reduce pathogen transmission. It also associated with higher preferences for health and attractiveness in mates. Higher fertility rates and shorter or less parental care per child is another association which may be a compensation for the higher mortality rate. There is also an association with polygyny which may be due to higher pathogen load making selecting males with a high genetic resistance increasingly important. Higher pathogen load is also associated with more collectivism and less individualism

which may limit contacts with outside groups and infections. There are alternative explanations for at least some of the associations although some of these explanations may in turn ultimately be due to pathogen load. Thus, polygyny may also be due to a lower male:female ratio in these areas but this may ultimately be due to male infants having increased mortality from infectious diseases. Another example is that poor socioeconomic factors may ultimately in part be due to high pathogen load preventing economic development.

REFERENCES

1. Ryan KJ, Ray CG. Sherris Medical Microbiology (4th ed.). McGraw Hill, 2004.
2. Watts Duncan. Six degrees: the science of a connected age. London: William Heinemann, 2003.
3. Preston Richard. The hot zone. Garden City, N.Y.: Anchor Books, 1995.
4. Ferguson NM, Donnelly CA, Anderson RM. The foot-and-mouth epidemic in Great Britain: pattern of spread and impact of interventions. *Science*, 292 (5519), 2001, 1155–60.
5. Ge D, Fellay J, Thompson AJ et al. Genetic variation in IL28B predicts hepatitis C treatment-induced viral clearance. *Nature*, 461 (7262), 2009, 399–401.
6. Thomas DL, Thio CL, Martin MP et al. Genetic variation in IL28B and spontaneous clearance of hepatitis C virus. *Nature*, 461 (7265), 2009, 798–801.
7. Krauss H, Weber A, Appel M. Zoonoses: Infectious Diseases Transmissible from Animals to Humans (3rd ed.). Washington, D.C.: ASM Press, 2003.
8. Beretta M. The revival of Lucretian atomism and contagious diseases during the renaissance. *Medicina nei secoli*, 15 (2), 2003, 129–54.
9. Robert Moorhead, William Budd and typhoid fever. *J R Soc Med*, 95(11), 2002, 561–564.
10. Nettle D. Ecological influences on human behavioural diversity: A review of recent findings. *Trends in Ecology & Evolution*, 24 (11), 2009, 618–611.