Answers to questions on the spread and control of diseases

List and discuss briefly major public health strategies for communicable disease control. Choose five communicable diseases and discuss what public health strategies will be appropriate in each case.

Major Public Health Strategies for Communicable Disease Control

The main public health strategies to control communicable diseases include all measures designed to prevent or reduce the incidence, prevalence and consequences of disease (WHO 1984). These measures are included in primary health care and involve participation of community, support from different government, public and private sectors and coordination between these sectors (WHO 1978). The control measures are directed against reservoir or sounce of infection, the root of transmission and susceptible host (people at risk).

i) Controlling Reservoir of Infection.

It includes early diagnosis or detection of cases or carriers, notification of disease, isolation, treatment and quarantine.

ii) Interrupting Transmission of Disease.

This is done by interrupting direct transmission and indirect transmission of infective agent from patient and carrier to susceptible host by changing some part of man's environment. The public health strategies to achieve this includes clean water supply, improving sanitation, proper cooking and refrigeration, improving personal hygiene, controlling vectors and proper handling of secretions and excretions of humans and animals.

iii) Protection of Susceptible Host or Patient at Risk

This includes active immunization, passive immunization, combination of active and passive immunization and prophylaxis by drugs.

iv) Other measures that have interrupted transmission of many diseases in developed countries include legislation for integrated and effective public health programs, improved quality of life and better education. Surveillance follows control measures.

Five Communicable Diseases and Public Health Strategies to Control them

1-Chickenpox is acute highly infectious disease caused by varicella zooster virus (VZV) usually in children. It spreads by airborne particles and direct contact. The control strategies are notification, isolation of cases for six days after the rash appears, disinfection of articles soiled with secretion from nose, mouth and skin and using gloves and face mask while attending patient. Antiviral drugs are effective if used in first 24 hours of appearance of skin rash. Human varicella zoster immunoglobulin is given to contacts and immunocompromrised. A live attenuated vaccine is available and used in US and some other countries for children at one year of age.

2-Measles is acute highly infectious disease of childhood caused by a myxovirus. The control strategies include routine vaccine coverage of all children at 9 months and 4 years of age using live attenuated vaccine. Catch up vaccination is done for children who miss out. Successive generations of children are vaccinated. Isolation in initial stages of incubation period and disinfection of articles can help control spread. Notification to local health

authorities, epidemiological investigation and health education are also necessary.

3-Diphtheria is caused by corynebacterium diphtheriae and affects upper respiratory tract. Control includes early detection of cases and carriers, notification, isolation in the hospital, and treatment of cases by diphtheria anti-toxin and carriers by erythromycin. Contacts are given booster dose of anti-toxin if they have not received in last two years and surveillance of close contacts is done for several weeks after exposure. On community bases the effective control is achieved by active immunization of diphtheria vaccine at age of six weeks, ten weeks, fourteen weeks, and booster doses sixteen to twenty-four months and five years.

4- Cholera is disease caused by vibrio cholera 01 (El Tor-most or Classical-less common). Main clinical manifestations are acute onset of diarrhea, massive fluid loss and shock.

WHO guidelines for control of diarrhea (p192)(ref19) include verification of diagnosis from stool examination, notification to local health authorities, early case finding, establishing treatment centers, rehydration of patients, antibiotics like doxycylcline, OTC or ciprofloxacllin, epidemiological investigation, sanitation, use of clean water and properly cooked food, parental or oral vaccination and health education with diarrhea control program.

5-Enteric fevers include typhoid and paratyphoid fevers caused by Salmonella typhi and S. paratyphi A and B. Disease spreads by ingestion of contaminated faeces, urine, food, water and poor personal hygiene. Control

measures includes control of reservoir by identification, isolation, treatment and disinfection; improving sanitation of food water and personal hygiene and using inactivated injectable vaccine and oral live attenuated vaccine.

Q2

Select an infectious disease of your interest. Provide a comprehensive account of clinical features, diagnosis, causative organism, mode (s) of transmission. Explain past and current disease prevention techniques used to control the disease with an emphasis on primary and secondary prevention measures.

Choose a country that is affected by that infectious disease described. Explain the disease burden, discuss relevant risk factors and discuss limitations or hurdles in the control and prevention of that disease.

Answer

Cholera

i) Definition: WHO defines cholera as " Cholera is an acute diarrhoeal infection caused by ingestion of food or water contaminated with the bacterium Vibrio cholera" (WHO, Fact sheet on cholera 2010). Cholera is caused by vibrio cholera serotype 01. The El Tor bio type more commonly infects than classical bio type.

ii) Pathogenesis: Enzyme adenyle cyclase is activated in intestinal wall by enterotoxin of vibrio cholera that activates cyclic-AMP leading to massive secretion of chloride and water from the intestinal endothelium. It infects both adults and children (Robbins, Stanley, Kumar, and Cotran 2010).

iii) Clinical Features: Sudden onset of severe diarrhoea without pain, vomiting. Stool is like rice water in color. Severe dehydration, shock and oliguria. Death occurs due to circulatory failure. In most of the cases diarrhoea is mild and occassionally disease is very severe with intense loss of fluid and dilatation of intestine leading to death. It is dangerous when disease occurs in children (Boon, Nicholas, and Davidson 2006).

iv) Diagnosis: During epidemic diagnosis can be made easily from clinical features. But confirmation of diagnosis requires laboratory methods. Specimen of stool is taken before anti-biotics are given. A fresh specimen of stool or rectal swabs are taken and transported via transport media or put in sterile container. In the laboratory direct microscopic examination with dark field illumination shows shooting star appearance of vibrio cholera against dark background. This test diagnosis in 80% cases of infection. Specimen can be cultured in bile salt agar medium over night and examined under oblique light for colonies. Serological tests like direct haemagglutination test and cholera phage type test are also available for phage typing (Robbins, Stanley, Kumar, and Cotran 2010) .

v) Causative Organism: Cholera is caused by vibrio cholera (serogroups O1 and O139 are cause outbreaks), sero-type O1 causing the majority of the outbreaks, while serotype O139 causes less outbreaks and it is limited to South-East Asia. Other serotypes non-O1 and non-O139 cause mild disease only (WHO, Fact sheet on cholera 2010).

vi) Modes of Transmission: Use of water contaminated with faeces from water wells, ponds, lakes and rivers for drinking purposes, consumption of

contaminated food, drinks, vegetables, and fruits, ingesting cooked food, contaminated due to handling with contaminated hands and exposd to flies. Transmission also occurs due to direct person to person contact when one have contaminated hands and fomites.

vii) Incubation period is from few hours to 2 days

viii) Prevention: Traditionally the preventive measures include coordination between public and private sectors to achieve clean water supplies, proper disposal of excreta and waste water, safe handling of cooked food, drinks and other edibles protecting them from flies and conteminated hands, behaviroal modification and health education and knowledge about imporatance of personal hygiene. Currently two oral whole-cell killed vaccines Dukoral and Shanchol are commercially available. These are effective and provide more than 50% protection from vibrio cholera (WHO, Prevention and control of cholera outbreaks: WHO policy and recommendations 2008).

Management: It includes replacement of fluid and electrolytes using intravenously ringer lactate when vomiting is present and oral fluids when there is no vomiting. Antibiotics, doxycycline 300mg or ciprofloxacillin 1gm or oxytetracycline 250 mg x 6hourly for 3 days reduces duration of diarrhoea and ammount of fluid loss (Boon, Nicholas, and Davidson 2006).

Cholera in Zimbabwe

The cholera epidemic in Zimbabwe began in August, 2008. According to WHO update June 9, 2009, cholera epidemic in Zimbabwe slowed down during 2009. The number of suspected cases of cholera was 98424 and

number of deaths due to the epidemic reached 4276. According to the information given in this WHO report, 4. 3% cholera patients have died due to cholera. The most of the reported cases of cholera (56%) affected Harare and its suburban areas, Beitbridge near South African border and Mudzi near Mozambique border.

(WHO, Global Alert and Response 2009).

Relavant risks factors are poor personal hygine, contaminated water and food, malnutrition, flies, migration, poverty and over crowding at camps. Limitations and hurdles to control cholera incude poor national efforts to find and control cases due to poor intersectorial coordination, political instabiity, emigaration of population, overcrowding near borders, insecurity and lack of resources for many immigrants to maintain proper food and sanitation, lack of health care providers and overstretched health care system.

Q3

Investigate the effect of global warming on the patterns of three diseases of your choice. Look at where these diseases are now found considering where they were not 20 years ago. What has enabled these diseases to spread? (i. e. was it the increase in temperature, the spread of the vector, change to a different vector etc?).

Answer

Malaria

Malaria is a parasitic infection and in humans it is caused by plasmodium falciparum, P. vivax , P. malarie and P. ovale and P. knowlesi. Malaria is transmitted when infected female Anopheline mosquito bites human. It

occurs in tropical and sub-tropical areas below altitude of 1500 meters. According to WHO estimates 300-500 million cases of malaria occur every year in the world and more than one million people die annually because of malaria (WHO, Water-related Diseases 2010).

Global Warming and Malaria: Global warming is leading to climate change in many regions of the world. There is increase in rains, rise in temperature and increased moisture that favors spread of insect vectors. This leads to increase in transmission of vector born diseases including malaria. Climate change or global warming is moving malaria to higher altitudes. Examples of spread of malaria are in highlands in Eastern part of Africa and Madagascar, People's Republic of Korea and the mountains of Papua New Guinea. These areas were malaria free 20 years back; are now experiencing seasonal epidemics. A model of predictions by Martens et al in 1995 showed that 3° C increase in global temperature by 2100 will increase the annual malaria cases by 50-80 million (Martens et al., 1995).

Causes of malaria spread: Environmental factors that help spread include temperature between 18° C to 40° C. At temperature lower than 16oC, development of plasmodium inside the mosquito stops. Humidity level of 60% is necessary for mosquito life. Rain provide breeding places. When a female Anopheline mosquito with sporozoites in her salivary glands bites human being it transmits malaria. Transfusion of blood containing malarial parasites and lack of prophylaxis can lead to spread of malaria.

Prevention and Control : Chemoprophylaxis is achieved by chloroquine, malarone, doxycycline or mefloquine. Vector control strategies include

indoor and outdoor spraying of insecticides, using insecticides treated nets and treatment of mosquito breeding sites with insecticides to eliminate them. The other measures are proper disposal of waste water and filling of waste water reservoirs (Boon, Nicholas, and Davidson 2006).

Dengue

In 1960 there was no case dengue fever, in 1990, the average number of cases reached above 400, 000 and in 2005 the number reached above 900, 000. In last twenty years geographical distribution of disease and number of cases have increased dramatically. The disease is endemic in south-east Asia, India, Africa, Caribbean and Americas (Mahr 2007).

Causative Organism and vector: Causative organism is dengue flavi virus with four serotypes and all produce similar clinical syndrome. Principal vector is mosquito Aedes Aegypti but Aedes albopictus is also a vector in south-east Asian countries (Mahr 2007).

Transmission: Reservoir of infection is man and mosquito. Transmission cycle includes man-mosquito-man. All ages and sexes are susceptible.

Factors leading to spread of the disease: Increasing population and urbanization lead to improper management of water supply and water storage in open containers. The mosquito breeds in standing water. Air coolers using water and tyre dumps contain stagnant water and act as breeding sites. Global warming leading increased rains causing stagnant water pool thus cause spread of vector. In south-east Asia additional vector Aedes albopictus may also participate in spread of disease (Mahr 2007).

Prevention: Main preventive strategies include abolishing Aedies mosquito breeding places and insecticide srpay to destroy adults. No vaccine is available (Boon, Nicholas, and Davidson 2006).

Clinical features: Incubation period is 2-7 days. Disease can be asymptomatic but it is more severe in infants and elderly. Severe disease is called dengue haemorrhagic fever and causes circulatory failure and systemic complication. Main clinical features are continuous fever for 4-5 days, headache, severe body pains, pain in eyes, nausea, vomiting, diarrhea and skin rash. Complications like internal and external bleeding occurs(Boon, Nicholas, and Davidson 2006).

Treatment: Symptomatic, fluid replacement and treatment of shock

Japanese Encephaitis (JE)

This is a mosquito-borne disease caused by Flavivirus. The vector is culicine mosquito. The disease predominantly affects children aged less than 15 years and has high fatality rate.

Effect of global warming on spread of disease: This is a zoonotic disease that infects animals and occasionally human beings. The disease was endemic in Japan, China and Korea 25 years ago but now it is found in large population of South East Asia. The global warming has lead to changes in the environment of South East Asia with increased humidity and increase in rains. This has resulted in increased breeding places of mosquito and spread of disease(Boon, Nicholas, and Davidson 2006).

Spread of Disease: Spread is through all serotypes of JE virus. The vector, culicine mosquito breeds in places containing water like rice water fields, water pools in jungles, ditches and fields. The reservoirs of virus are pigs and aquatic birds (Park 2008).

Clinical Features: It is a systemic illness with fever, headache, vomiting, photophobia, seizures and paralysis.

Control: By vector control using insecticide sprays in the fields, use of mosquito nets and vaccination of population at risk.

Q4.

Summaries of Readings

Nelson K, Williams C. (2007): Early History of Infectious Disease: Epidemiology and Control of Infectious Diseases. In Infectious Disease Epidemiology Theory and Practice, 2nd edition. Jones and Bartlett Publishers, USA.

This article describes early epidemics of infectious diseases in ancient civilizations, the gradual development of knowledge of infectious diseases and their control and development of public health measures and their role in infectious disease control in western civilizations.

The ancient history of Greece and Egypt mentions epidemics of infectious diseases that killed kings as well as common people in large number. Political unrest and massive dislocation as a result of wars helped spread of diseases. From the writings of early historians researchers think these epidemics were due to smallpox, tuberculosis, diphtheria and meningococcal infection. The bubonic plague epidemics with other communicable disease

caused wide spread epidemics in 160CE and 165-180CE in Europe leading demise of Hans and Roman empires and killing 5 million people. The plague epidemics occurred again in 12th and 14th centuries in Europe and killed massive number of Europeans. In cities people with better immunity survived. Small pox epidemic occurred in 14th century BCE in Egypt. Latter on it was disseminated in Europe. Wars and invasion disseminated it to Americas and killed hundreds of thousand people as they have no immunity against it. At that time it became known that skin lesions transmit disease and survivors were immune to re-infection. Deliberate exposure to disease was a practice used in China and India before its use in Europe.

Hippocrates (460-377 BCE) in his treatise stated that environmental factors were responsible for occurrence of disease. Claudius Galen (131-201 CE) used ideas of Hippocrates and his knowledge of anatomy and physiology from animals and humans to describe his ideas in his writings. His writings were used in Europe till The Middle Ages. The contagious nature of infectious diseases were known but control measures were ineffective due to lack of knowledge of epidemiology. In case of plague, infected cases were quarantined and possessions and corpses were disposed off. The importance of rats and fleas in the epidemic of disease was not recognized. The lepers were considered as sinners during The Middle Ages. Fracastoro (1478-1553) presented the idea that transmission of infectious disease from one person to another was due to minute particles. The disease was transmitted by direct contact, by fomites and through air.

The process of variolation, means intentionally inoculation people to induce immunity was advocated by scientists. Mather (1663-1728) described it in

his slave. Edward Jenner (1749-1826) successfully inoculated cowpox in a boy to induce immunity against smallpox. This was first clinical trial of a vaccine. The small pox vaccination lead to its eradication two centuries later. Napoleon vaccinated his army against smallpox. Thomas Sydenham(1624-1689) advocated and differentiated various febrile illness by careful observation and many others adopted same strategy to describe illnesses including infectious diseases. John Snow (1813-1858) and William Budd (1868-1953) performed epidemiology of cholera and typhoid fever respectively before isolation of organisms. The other scientists started careful clinical observation, diagnosis and measure to control and treat patients.

John Graunt(1620-1674) documented number and causes of death in London during a third of century, ratio of births and deaths of both sexes and these ratios in rural and urban areas and constructed life tables. The public health data was used to study infectious disease epidemics. It was also used to implement sanitary reform in London and proving cost-effectiveness of public health measures. Analytic use of public health data was introduced by William Far(1807-1883)

Leeuwenhoek (1632-1723) invented microscope and described bacteria and spirochetes in fecal material and rain water. Louis Pasteur (1822-1895) showed that microorganisms cause fermentation and Robert Koch (1843-1910) showed microorganism cause disease. Later on other scientists discovered microorganisms as causative agents for various infectious diseases and the vectors responsible for transmission of causative agent.

The yellow fever virus was discovered in 1898 by Reed. It was discovered

that yellow fever virus is transmitted by mosquito Aedes aegypti. Malarial parasite was discovered by Alfonse Laveran in 1880. Ronald Ross discovered life cycle of avian malaria and Grassi discovered anopheline mosquito were vector for malaria and avian life cycle was same in humans.

The knowledge of microorganisms that cause infectious diseases, the progress in bacteriology, immunology, virology, statistics have helped in understanding of epidemiology of infectious diseases. But still infectious diseases cause many deaths and outbreaks in various parts of the world every year.

Discovery of penicillin by Alexander Fleming and subsequent development of various antibiotics has made treatment of infectious diseases possible. The public health officials and epidemiologists now assist health authorities in control of infectious diseases. Advancements in public health have increase the average life span of

Infectious disease challenge: The advancements in genetics, virology and antiviral therapy had modified course of many infectious diseases. The older techniques of diagnosis and management of disease are being replaced with new ones. But still the challenge of infectious disease control remains ahead.

Overview of the Control of Disease

This article deals with control of infectious diseases during 20th century and challenges ahead during 21st century.

During 20th century, there was decline in infant mortality that resulted 29. 2 years increase of life expectancy. During 19th century, more than 30%

deaths occurred in children under 5 years of age which dropped to 1. 4% in 1997. In 1900, leading causes of death were pneumonia, tuberculosis diarrhea and enteritis. While in 1997, the main causes of death are heart disease and cancers. The decline in death rate during 20th century can be attributed to discoveries of 19th century like micro-organisms, improvements in sanitation and personal hygiene. The implementation of mass vaccination programs, invention of antibiotics, disease surveillance and control systems can be due to scientific advancements.

Industrialization and mass movement of people towards cites during 19th century lead to epidemics of infectious diseases due to overcrowding, poor housing, poor person hygiene and poor sanitary measures. During 20th century chlorinated water supplies, proper waste disposal, better housing, better animal and pest control, use of disinfectants and application of sanitation measures in ships lead to decline infectious diseases. Mass vaccination programs caused fall in tuberculosis, diphtheria, tetanus and polio. Measles, mumps and rubella infections were also controlled. Vaccination Assistance Act helped continuous supply of childhood vaccines. Antibiotics and other antimicrobial drugs help control TB and other infections. Technological advances lead to serological testing and control of viral diseases.

During 21st century continuous need of research into mortality and morbidity is needed to control and treat infectious diseases. Appearance of AIDS and some other infections show evolution in microbes. Molecular genetics show the appearance of drug resistant strains of microbes. For

future success public health needs to address these and other upcoming

challenges.

Chase, A. (1982): Magic shots. William Morrow and Company Inc., New York.

This article describes history of development of smallpox vaccine by Edward

Jenner in 1796, the behavior of political, social, religious forces and scientists

related to use of this vaccine in Europe and USA, the history of epidemics of

smallpox, WHO campaigns for eradication of smallpox and finally eradication

of smallpox.

The Chinese and Indians knew before Christian era that material from

smallpox lesions can be used to induce long lasting immunity in health

individuals while Europeans lacked this knowledge. During 18th century the

physicians in Western world started vaccinating affluent people with infected

material from smallpox patients (called variolation) this caused active

disease in 5-10% of variolated individuals, high mortality and severe

complications. This led to banning of variolation practice in some US states.

The smallpox was introduced into Europe as a result of Holy Crusade during

first two centuries of second millennium. The crusaders infected with

smallpox returned back to Europe and spread the disease. The smallpox

existed in India, China, Egypt and Greece since thousands of years. Of and

on epidemics killed hundreds of thousands of people and blinded and

disfigured many due to complications. The smallpox was introduced to

Americas by Spanish and European settlers. It was unknown there before so

Native Americans did not have immunity against it. It resulted in numerous deaths devastating their civilizations.

Edward Jenner, a Scottish physician noted that milk maids developed mild form of disease after they came in contact with lymph and secretions in the lesions of cows with cowpox. This was without complications and subsequently they became immune against smallpox. He was also aware that many people in cattle business inoculate themselves with lymph from cowpox pustules and become immune against smallpox. Jenner inoculated an eight year old boy with lymph from cowpox lesion (cowpox virus) by scratching his skin. The boy developed mild cowpox. After few weeks Jenner inoculated the same boy with lymph taken from smallpox patient, the boy did not developed smallpox. The inoculation of boy with lymph from other smallpox patient also did not cause smallpox in him. Jenner then repeated the experiment on other people and found that all developed immunity against smallpox after inoculation with lymph from cowpox. This was invention of a very safe and effective smallpox vaccine and beginning of immunology.

Although during 18th CE smallpox was a major cause of death in Europe killing 15 million people every 25 years. Many influential people opposed use of Jenner's smallpox vaccine due to various reasons.

Industrial revolution resulted increase in population of poor areas of cities, sanitation issues and epidemics of all infectious diseases including smallpox. The English rich ruling class wanted Jenner's vaccine for themselves and their families only. They allocated very small funds for its use in Ireland, and

were against mass vaccination of public. The conservative religious riches considered saving poor from smallpox will disturb balance of nature and increase their population. The cost benefit analysis by experts was also used to show that mass vaccination was uneconomical. The English and French armies got vaccination against smallpox. Napoleon favored Jenner's vaccine. Malthus and his supporters successfully opposed mass vaccination and other public health measures in Britain. Many of the colleagues opposed smallpox vaccination due to professional jealously with Jenner while other supported recognizing its benefits. The German and Scandinavian ruling class supported and implemented mass vaccination during early part of 19th century decades before the English did so.

In US Dr Benjamin Waterhouse a professor at Harvard visited Europe, became aware of smallpox vaccine and wrote President Thomas Jefferson, Vice-President at that time about the global eradication of smallpox. Jefferson agreed and appreciated the idea. The smallpox vaccine was imported and also prepared in US and small level vaccination was started. There were forces of opposition like England that slowed progress of vaccination. Shattuck Report in 1850 examined state of public health affairs in Massachusetts and stressed periodic vaccination of people along with all the sanitary measures. Immigrants from China and Europe, slaves from South and local poor provided cheap labor and were unable to afford proper housing and sanitation. They lived in crowded dwellings suitable for infectious disease epidemics including smallpox. The outbreaks occurred between 1820-1870 killing hundreds of thousand people.

In Europe, during smallpox pandemic during 1870-1875, the dead rate in countries without compulsory vaccination was four times higher than those with compulsory vaccination

Smallpox became internationally notifiable disease in 1926. WHO launched campaigns to eradicate smallpox from the world. First two campaigns failed but the third become successful and the last case of smallpox was reported in Somalia in 1977. Bureau of Smallpox Eradication became part of CDC in 1966 to endure safe vaccination against smallpox. The complications of smallpox vaccination are insignificant. World is global village and US and other countries can remain free of infectious diseases if they help less fortune countries to improve sanitation, overcrowding, personal hygiene, safe water supplies and other public health measures.

Giesecke J. (2002). Mathematical models for Epidemics. In Modern Infectious Disease Epidemiology. London.

Mathematical models are used in weather forecasting, economics and sociology. They are based upon certain assumptions, take more important factors as determinants of development and used for predictions and other protocols. These models are also useful in infectious disease epidemiology.

Basic reproductive rate (Ro) gives average number of people who gets directly infected by an infectious case during infectious period in a susceptible population. During an epidemic current reproductive rate (R) is used. In an epidemic when R is greater than 1 shows disease will disappear when it is equal to 1, it will become endemic and when R is larger than 1 it becomes epidemic.

When a proportion p of a population already immunized, p x R0 people will not catch infection and R – p x R0 will be infected. Since epidemic occurs when R – p x R0 is greater than 1so increasing secondary immunization level in a population increases value of p x R0 and epidemic does not occur.

We can represent this relationship in a simple formula.

R – p x R0 < 1 OR p > (R0 -1) / R0

The determinants of Ro are risk of transmission per contact ($\hat{I}^2$), the number of contacts of an average person in a population ($\hat{I}^\underline{o}$) and during of infectivity of a person (D). Mathematically we can show the relationship

Ro = $\hat{I}^2$ x $\hat{I}^\underline{o}$ x D

The infections with high infectivity and longer immunity (childhood diseases), Ro estimation can be from average age at infection time. The formula R0 = 1 + L/A where L is average life span of a person and A is age when infection occurred.

Researchers discuss a simple model of infectious disease making assumptions that disease occurs in a fixed population with zero latent period having duration of infectivity equal to clinical manifestation of disease. The population of size n can be divided into three proportions namely S, susceptible portion of n; I, currently infected and infectious proportion of n and R, immune proportion of n.

Before infection S= 1 while I and R are 0. With the spread of epidemic S decreases R increases and I first increases then decreases. Three equations can be setup and during epidemic these will be

dS/dt = – β x γ x S x I —-(a)

dI/dt = β x γ x S x I-I/D —-(b)

dR/dt = I/D—-(c)

Here eq.(a) shows proportion of susceptible people is decreasing. Eq (b) show