CHAPTER – 1

INTRODUCTION

1.1 About Dengue

Dengue is a reemerging disease mainly in cities throughout the world. This fever can go up to 39.5 degree to 41.4 degree Celsius. (i.e) 103.1 – 106.52 degree Fahrenheit (Reiter et al., 2003). It is accompanied by headache and bone pain. There are also other symptoms like, vomiting, loss of appetite, pain in eyes, and rashes on skin, low BP, drowsiness, severe exertion, bleeding from any body part, rapid fall in platelets etc. But there is no need to panic and no platelet transfusion is required unless platelet count is less than 10,000 or there is a presence of spontaneous bleeding. During epidemics, people of all ages are involved otherwise the disease is more common in children. They affect the white blood cells first. Dengue illness is mostly confused with the other viral diseases. This fever may disappear and then reoccur along with skin rashes (Wolff & Johnson 2009). There is no drug available for the specific treatment of dengue (Dengue and severe dengue n.d). This is also called break bone fever. The symptoms of dengue are evident within 2-7 days of infected mosquito bite. This disease kills nearly 3 millions of people in a year (Dengue and severe dengue n.d ). Massed et al., (2011) stated that people infected by dengue virus are asymptotic around 80%. There is a need for a mathematical model for the spread of dengue in order to protect people against it. The model can enhance our understanding of the problem and help us make proper assessment of the present and future risk areas or spread of a disease and to evaluate the strategies to combat such a dangerous disease, Dengue.

This fever found in tropical and subtropical regions both in urban and semi urban areas. Dengue infections are caused by four closely related viruses named DEN-1, DEN-2, DEN-3, and DEN-4 (Chen & Wilson 2006). These viruses are members of the virus family Flaviviridae and are transmitted to people through the bite of the mosquitoes Aedes aegypti and Aedes albopictus. According to WHO (2008), Aedes albopictus is a kind of mosquito
that can transmit the dengue virus and the presence of the species was detected in Asia in recent years. However, *Aedes aegypti* are still the principal vector of dengue virus transmission. *Aedes aegypti* are pests. Bites cause minor localized itching and irritation to the skin, and can make an outdoor adventure very unpleasant. Most bites are not medically significant, but can be annoying. While many mosquitoes bite at night, dawn or dusk, *Aedes aegypti* readily bite during the day and indoors as well as outdoors. Dengue is also known as "break-bone fever" for the excruciating pain it causes in the victims. Although a person can get immunity to one serotype, they are still susceptible to the others. The most deadly is dengue hemorrhagic fever (DHF), which is often fatal.

Another interesting fact is the shift of patient’s phenomena where dengue fever previously attacks children of primary school age, but now everybody is vulnerable to the fever (Pongsumpun, P & Tang.I 2001). These four viruses are called serotypes because each has different interactions with the antibodies in human blood serum. These viruses are transmitted in a large number to humans by infective female *Aedes Ageypti* mosquito due to the population of these mosquitoes (Gubler 1998).

The above figure 1.1 shows the Adult female yellow fever mosquito, *Aedes aegypti* (Linnaeus) (Linnaeus) in the process of seeking out a penetrable site on the skin surface of its host. (James Gathany, Center for Disease Control Public Health Image Library).

In tropical regions, the life span of adult female mosquitoes ranges from a few days to several weeks and it is frequently longer in temperate regions. Laboratory studies showed that male and female Aedes mosquito survive an average of 20 to 30 days respectively depending on environmental conditions. Mosquitoes are among the best
known groups of insects, because of their importance to man as pests and vectors of some of the most distressing human diseases. The transmission cycle is “man-mosquito-man”.

*Aedes aegypti* bite primarily during the day. This species is most active for approximately two hours after sunrise and several hours before sunset, but it can bite at night in well lit areas. This mosquito can bite people without being noticed because it approaches from behind and bites on the ankles and elbows. *Aedes aegypti* prefer biting people but they also bite dogs and other domestic animals. Only female mosquitoes bite to obtain blood in order to lay eggs as they need protein to develop eggs and they (female mosquito) can only transmit the virus (Gubler 1998).

![Fig. 1.2. Stages in Dengue Fever](image)

Under optimal conditions, the egg of an *Aedes* mosquito can hatch into a larva in less than a day. The larva then takes about four days to develop into a pupa, from which an adult mosquito will emerge after two days. Three days after the mosquito has bitten a person and taken in blood, it will lay eggs, and the cycle begins again. The mosquito becomes infective approximately seven days after it has bitten a person carrying the virus. This is the extrinsic incubation period, during which time the virus replicates in the mosquito and reaches the salivary glands. Peak biting is at dawn and dusk. The mosquito can lay eggs about three times in its lifetime, and about 100 eggs are produced each time. The eggs can lie dormant in dry conditions for up to about nine months, after which they can hatch if exposed to favorable conditions, i.e. water and food. (The Aedes Mosquito, National environment agency n.d).
Fig. 1.3. The stages of Dengue infection

The above figure, fig. 1.3 (El Dengue, 2006) shows the various stages in dengue infection.

1.2 Adult mosquito

One may be confused with the word adult mosquito. The male mosquito usually emerges first and lingers near the breeding site, waiting for the females. After breeding, larvae are created and then it becomes an adult mosquito. On an average, a female mosquito lives three to six weeks, but can live up to five months. The male's life span is much shorter. Both adult male and female feed on nectar and plant fluids, but it is only the female that seeks a blood meal, which most species need in order to develop their eggs. Female mosquitoes lay multiple batches of eggs and most species require a blood meal for every batch they lay. Females of some species can develop a limited number of egg batches (usually just one) without taking a blood meal, a quality known as "autogeny."

The figure, fig.1.4 (The mosquito, 2006) shows that the different stages of aedes aegypti. In tropical regions, adult mosquitoes are active throughout the year, but in other areas they become inactive when the temperature drops below 60°F and usually enter hibernation when the seasonal cool temperatures arrive. A few mosquito species hibernate as larvae, usually buried in moist swamp muds, but most overwinter either as eggs laid by
the last generation, or as adult, mated females that spend the winter in protected locations such as hollow trees, animal burrows, or attics.

The average *Aedes aegypti* mosquito will disperse relatively short distances and travel no more than 500 metres in its lifetime. (Eliminate dengue our challenge, n.d).

The figure, fig.1.5 shows that the dengue endemic area, in particular India since 1975-1998.
1.3 Dengue status

India has been one of the dengue endemic areas since ancient days. The following figure, fig.1.6 (Dengue matters - countries of areas at risk of dengue 2009) shows a survey of dengue endemic areas in 2009. India is one of the dengue endemic areas.

According to Shrikant Sharma (2013), only 1 in every 13 patients suffering from dengue consults a doctor. Mortality rate of in Dengue fever cases is 1-2%, (Myths-and-facts-about-dengue, 2013).
The above figure, fig.1.7 shows that the cases are very drastically fluctuating from 1991 to 2006. From 1991-1996 there was the increasing trend whereas from 1997 to 2000 there were very lower number of cases, again from 2001 it is in increasing trend. In 2013 dengue outbreak in the country was the worst in the last six years, with 75454 cases being reported. According to health ministry data, the number of dengue cases has been steadily rising since 2008, when the count was 12,561 and witnessing a dip only in 2011 in India.
The number of deaths due to the disease has increased from 80 in 2008 to 167 in 2013, although it is far lower than 242 recorded in the year 2012. Disease is prevalent throughout India in most of the metropolitan cities and towns. The above graph, fig.1.8 shows that the deaths in India are increasing from 2003 to 2006 except 2004 and also steadily increasing from 2007 to 2012. The graph, fig.1.9 shows that the dengue cases are steadily increasing from 2007 to 2013 except 2011 but the cases are comparatively high.

![Graph showing dengue cases in India from 2003 to 2013](image)

Fig.1.9 Dengue cases in India from 2003 to 2013

Since then several outbreaks of dengue fever have been reported from India with a major epidemic of dengue fever that occurred in Delhi in 1996 when 10 252 cases and 423 deaths were reported all over India. Cases were reported from the neighboring states of Haryana, Punjab, Rajasthan, Utter Pradesh and two southern and western states. DEN-2 was isolated during this epidemic. The number of DF cases and deaths reported since the epidemic had been low till 2002 but again had risen in 2003. In 2005, both the reported dengue cases and deaths showed threefold increase as compared to 2004. The case fatality has been above 1% for the last few years.

In 2006 the number of cases reported as compared to 2005 showed some reduction whereas the Case fatality rate had remained above 1%. However, the number of reported dengue cases and deaths were mainly from the capital city Delhi and the other states that had small outbreaks which went unreported. Therefore the case surveillance needs
further strengthening. There is need to step up case surveillance system. *Aedes aegypti* were reported from all the affected areas with house indices exceeding 20%. Surveillance activities have been carried out on a limited scale by the National Institute of Virology, Pune, and few other institutions in the country. Since 1996, dengue control activities are coordinated and carried out by the National Anti-Malaria Programme. The central Cross Checking organization field Unit of NVBDCP has checked 5083 houses, 6236 containers. The indices as compared to the month of May 2006 were found higher.

The trend data from India showed that cases generally start to increase from August onwards, which is post monsoon season. More importantly, it is clear from the data that breeding of *Aedes* mosquitoes however begins in June itself. Such data may be taken into consideration, while planning in advance for dengue prevention and control. Thus vector surveillance and control measures supported by community mobilization for behavioural change activities need to be taken before June and sustained throughout the rainy season.

Fig: 1.10. Dengue endemic areas in India 2013
In India, the risk of dengue has shown an increase in recent years due to rapid urbanization, lifestyle changes, and deficient water management. Improper water storage practice in urban, periurban, and rural areas leads to proliferation of mosquito breeding sites. The disease has a seasonal pattern, the cases peak after monsoon and are not uniformly distributed throughout the year. Dengue is widely prevalent in India. All four serotypes are found in the country (World Health Organization. Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. Geneva: World Health Organization and the Special Programme for Research and Training in Tropical Diseases, 2009). Since 1996, the area of endemicity has been increasing with about 450 million population at risk throughout the world. Figure 1.10 (Dengue endemic areas in India 2013) shows the dengue endemic areas of India in 2013. At present dengue is endemic in India in 23 states/Union Territories.

Infact, these Aedes aegypti mosquitoes not only bite human but also birds and animals. Corvids, crows and jays were the hardest hit among the birds; other passerines such as sparrows also carried the virus but were dying in smaller numbers. Among mammals, horses appeared especially vulnerable, with a mortality rate of approximately 40% (Wonham, M et al., 2004). In this thesis, only human is considered