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# Effects of Awareness on Dengue: A Mathematical Approach

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**Abstract**: Dengue is a mosquito-borne disease spreading very rapidly in the world..It is spread among human beings by the bite of an infected ***Aedes*** mosquito. In the present paper, the effects of awareness on Dengue is discussed.The awareness of the disease is important so that people can take timely and effective preventive measures and go for required tests and check-ups. Lack of awareness and knowledge can be a serious barrier to a person's health.The population dynamics and associated basic reproduction number is discussed in this paper using a system of differential equations. Stability analysis is used to determine the dynamical behaviour of the system.

**Keywords**: Dengue, Stability, Awareness, Basic reproduction number

## I. INTRODUCTION

Dengue is one of the most common vector-borne viral disease currently affecting over 50 million people in tropical and subtropical areas each year [1] . This virus mainly has 4 serotypes :- DENV-1, DENV-2, DENV-3, DENV-4 [2] . This virus is a member of the Flavivirusgenus [3]. About 1000 years age similar types of virus genomes were found in infection cycles using non-human primates and infected mosquitoes, while the viruses started spreading among human beings only a few hundred years ago[4][5]. Victims infected with DENV can show a variety of symptoms including mild flu-like syndromes , dengue fever or Severe Dengue Disease(SDD) , dengue haemorrhagic fever and dengue shock syndrome[6][7][8] .

Several unsuccessful methods were used to treat the dengue fever due to lack of knowledge about the severity of this disease at the early stages of the infection as victims with mild dengue fever posed a threat to develop severe dengue disease later on [7]. Studies about symptoms associated with SDD were largely inconclusive. It was found that male victims having dengue feverposed a major threat of getting SDD (OR: 2.3, 95% CI: 1.1–4.5, value 0.021) [9], while there was no association with SDD [10, 11]. Symptoms like vomiting, skin rashes, abdominal pain, bleeding were associated symptoms of having SDD [9–14].

High genetic homology is shared among the 4 DENV serotypes. Their amino acid sequence varies by about 25 to 40%. Genotypes which are within a serotype are much more conserves, and they have 3% variation in amino acid sequence [4][15]. When an infected mosquito bites a human , the virus gets transmitted into his/her body. When a mosquito is infected by the virus, a particular amount of time is required to replicate and disseminate throughout the insect before it is transmitted to susceptible humans: this period of time is called the **extrinsic incubation period** (EIP), and this period ranges between 5 and 15 days [16]. The more the lifespan of mosquito is nearer to the EIP, the less will be the probability of dengue transmission. Aedes aegypti *and* Aedes albopictusare the 2 types of vectors mainly responsible for the transmission and between them, the most competent vector is Aedes aegypti. It prefers, to obtain its meal(blood) from human's body, and mostly breeds near or inside artificial water containers such as pots, rain-water containers and discarded tyres . Various environmental and climatic factors contribute the life span of these mosquitoes which include temperature, rainfall and humidity [17].

## II. OBJECTIVES

The primary aims of this research are as follows:

Evaluate the current awareness level regarding dengue fever and its associated preventive measures within the urban underprivileged population in India, drawing insights from contemporary research.

Analyze the efficacy of intervention programs designed to prevent dengue fever among impoverished urban communities in India by conducting a comparative analysis of published data.

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## III. METHODS

Vector control remains the sole viable approach for the primary prevention of dengue. Multiple interventions for dengue vector control are currently in use, though their efficacy and community impact lack comprehensive substantiation. This systematic review is dedicated to consolidating and assessing the available global evidence on the community-level effectiveness of dengue vector control measures [18].

## IV. SEARCH STRATEGY

To search for published literature related to dengue intervention, transmission risk assessment, health education-based intervention impact, and vector control interventions, you can use the following modified search query: "KAP on dengue intervention" OR "assessing dengue transmission risk" OR "impact of health education-based intervention" OR "vector control interventions to prevent dengue". This query combines the various search terms within parentheses and uses the OR operator to search for articles containing any of these specific phrases. This will help to retrieve literature related to these topics.

We conducted a systematic search for publications using four databases: Scopus, PubMed, Cochrane Library, and Google Scholar. Scopus, PubMed, and Cochrane Library were selected for their comprehensive coverage of peer-reviewed articles. Additionally, we included Google Scholar to encompass a wider range of grey literature, recognizing the limited availability of publications on dengue intervention involving community participation [18].

## V. ELIGIBILITY CRITERIA

Our literature search encompassed all dengue-related articles, theses, and review papers published before June 2020. We focused on studies conducted in developing countries, as defined by the World Bank's criteria, and refined our search to include only publications available in the English language [18].

## VI. DEVELOPMENT OF MATHEMATICAL MODEL

We consider that mosquito population is facing an infectious disease. Let $S_h$is the Susceptible human, A is the Aware individual, $I_h$ is the Infected Human,$Im$ is the Infected Mosquito, $\alpha_1$ is the Rate of transmission of dengue infection from infected mosquito to human,$d_1$ is the natural death rate of human, $d_2$ is the Natural dath rate of mosquito.

- $\frac{dS_h}{dt}=\lambda_h-\alpha_1\frac{s_h}{p(t)}-m_1 s_h-d_1\,S_h-\nu_{2^{I_h}}$
- $\frac{dA}{dt}=m_1S_h+\nu_{1^{I_h}}-d_1A$
- $\frac{dI_h}{dt}=\alpha_1\frac{S_h}{P(t)}\mathrm{Im}-\nu_{1^{I_h}}-d_1I_h-\nu_2I_h$
- $\frac{dIm}{dt}=\alpha_2\left(\frac{\lambda m}{d_2}-\mathrm{Im}\right)\frac{I_h}{P(t)}-d_2\mathrm{Im}$

## VII. EXISTENCE AND LOCAL STABILITY ANALYSIS OF THE EQUILIBRIUM POINTS

There are eleven equilibrium points of the given system of equations. The equilibrium points are,

$$E_0(0,0,0,0), E_1\left(\frac{\lambda_h}{m_1+d_1},0,0,0\right), E_2\left(\frac{\lambda_h}{m_1+d_1},\frac{m_1}{d_1}s_h,0,0\right),$$
$$E_3\left(S_h^{(3)},0,I_h^{(3)},I_m^{(3)}\right)$$

Where,

$S_h^{(3)},I_h^{(3)},I_m^{(3)}$ Satisfy the following system of equations

$$\lambda_h-\alpha_1\frac{S_h^{(3)}}{p(t)}I_m^{(3)}-m_1S_h^{(3)}-d_1S_h^{(3)}-\nu_2\;I_h^{(3)}=0,$$

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$$\alpha_1 \frac{S_h^{(3)}}{p(t)} I_m^{(3)} - \nu_1 \; I_h^{(3)} - d_1 I_h^{(3)} - \nu_2 I_h^{(3)} = 0,$$

$$\alpha_2 \left(\frac{\lambda m}{d_2} - I_m^{(3)}\right) \frac{I_h^{(3)}}{P(t)} - d_2 I_m^{(3)} = 0.$$

The interior point of the system is given by,

**E*($s_h^*, A^*, I_h^*, I_m^*$)**

Where,

$\lambda_h - \alpha_1 \frac{s_h^*}{p(t)} - m_1 s_h^* - d_1 s_h^* - \nu_2 I_h = 0$ $\quad \alpha_1 \frac{s_h^*}{P(t)} I_m^* - \nu_1 I_h - d_1 I_h^* - \nu_2 I_h^* = 0,$

$m_1 s_h^* + \nu_1 I_h - d_1 A^* = 0$ , $\quad \alpha_2 \left(\frac{\lambda m}{d_2} - I_m^*\right) \frac{I_h^*}{P(t)} - d_2 I_m^* = 0$

- **Lemma 1:** The equilibrium point $E_1$ is locally asymptotically stable if,

$$(\nu_1 + \nu_2 + d_1) d_2 \; - \; \frac{\alpha_1}{P(t)} \frac{\lambda_h}{(m_1 + d_1)} \frac{\alpha_2}{p(t)} s_m < 0$$

- **Lemma 2:** The equilibrium point $E_2$ is locally asymptotically stable if ,

$$(\nu_1 + \nu_2 + d_1) d_2 \; - \; \frac{\alpha_1}{P(t)} \frac{\lambda_h}{(m_1 + d_1)} \frac{\alpha_2}{p(t)} s_m < 0$$

- **Lemma 3:** The equilibrium point $E_3$ is locally asymptotically stable if,

The roots of the characteristic equation
$\lambda^4 + A_1\lambda^3 + A_2\lambda^2 + A_3\lambda + A_4 = 0$ of the Jacobian Matrix satisfy the following conditions,
i.e $A_i > 0$ (where, i=1,2,3,4), together with $A_1A_2 - A_3 > 0$ and $A_1A_2A_3 - A_1^2A_4 - A_3^2 > 0$.
Where,

$A_1 = -(a_{11} + a_{22} + a_{33} + a_{44})$,

$A_2 = a_{11} a_{22} + (a_{11} + a_{22})(a_{33} + a_{44}) + a_{33} a_{44} - a_{34} a_{43} - a_{13} a_{31}$,

$A_3 = -(a_{11} a_{22}(a_{33} + a_{44}) + (a_{11} + a_{22})(a_{33}a_{44} - a_{34} a_{43}) - a_{31} a_{22} a_{13} - a_{31} (a_{13} a_{44} - a_{14} a_{43}))$,

$A_4 = a_{11} a_{22}(a_{33}a_{44} - a_{34} a_{43}) - a_{31} a_{22} (a_{13} a_{44} - a_{14} a_{43})$.

$a_{11} = -\frac{\alpha_1 I_m}{P(t)} - m_1 - d_1$, $a_{22} = -d_1$, $a_{33} = -\gamma_1 - \gamma_2 - d_1$, $a_{44} = -d_2 - \alpha_2 \frac{I_h}{P(t)}$,

$a_{13} = \gamma_2$, $a_{14} = -\frac{\alpha_1 S_h}{P(t)}$ , $a_{31} = \alpha_1 I_m P(t)$ , $a_{34} = \frac{\alpha_1 S_h}{P(t)}$ , $a_{43} = \frac{\alpha_2 S_m}{P(t)}$

## VIII. CONCLUSION

Dengue is a global public health problem because it is spread among human beings by the bite of an infected ***Aedes*** mosquito. It can spread very easily and can collapse the whole medical sector. It is considered as seasonal outbreak so we should take necessary precautions and awareness during the season. Precautions like sanitary improvements, cleaning stagnant water around our house, mosquito repellent are essential to control this public health problem. There is an urgent need for effective health education campaign aimed at preventing and treating Dengue infection in the community through medical institutions and medical agencies as well as mass awareness.

In this study we established a deterministic mathematical model for the transmission dynamics of Dengue virus with awareness among the human population. It was shown that the model is mathematically and epidemiologically well posed. The equilibrium points of the model equations found out, existence condition and stability analysis of the model discussed analytically.

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