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DESIGNING A FUZZY EXPERT SYSTEM ON AGE SPECIFIC PREVALENCE OF ARTHROPOD AND ZOONOSES DISEASES USING FUZZY MARKOVIAN CHAIN

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Abstract

In this paper, we take steps to calculate the age specific member rate using fuzzy Markov chain. We designed the definition of possibility distribution function. Based on the definition of possibility distribution function introduced, the fuzzy Markov chain was framed. For the calculation of age specific member rate of Arthropod and Zoonoses diseases, we designed an expert medical system. From which, an index was made for the age specific member rate which varies as the product of proportion of susceptible at a given age t and the possibility of becoming infected in two age/time steps. The calculated algorithm is compatible with the modern epidemiology of Arthropod and Zoonoses diseases as reported in the literature.

1. Introduction

Of all arthropod borne viral diseases, Dengue fever is the most common. Dengue fever

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Key Words : *Fuzzy set, Complement of fuzzy set, Fuzzy relation, Max.-Min. Composition of fuzzy set, Fuzzy restriction, Relational assignment equation, Possibility distribution function, Fuzzy Markov chain, Age specific member rate, Arthropod and Zoonoses diseases.*

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is one of the most important emerging diseases of tropical and subtropical regions. Dengue fever is a self limiting disease and represents the majority of cases. Malaria is protozoal diseases caused by infection with parasites of the genus plasmodium. Filaria is major public health problem in India. It is a protozoal disease. Yellow fever is a zoonotic disease caused by an arbo virus and transmitted by mosquitoes. Japanese encephalitis is a mosquito borne diseases caused by virus. Through all the diseases are not fatal, the disease is responsible for considerable suffering, deformity and disability.

Many mathematical models based on deterministic approach involving the differential equations and stochastic approaches were used in mathematical epidemiology. The stochastic approach can describe the epidemic process more precisely. It has been shown that the epidemic process of Arthropod and Zoonoses diseases is a two state fuzzy Markov chain so that it is appropriate for the stochastic model to be applied to it. The stochastic model of the Markov chain can give precise and reliable results for different patterns of age specific prevalence of diseases. Two step transition are used in the index of age specific member rate to show both age and time effects, which is validly based on the assumption that the age effects are stable over time. Lofti A. Zadeh mentioned the mathematics of fuzzy which are not described in terms of probability distributions. Yoshida constructed a Markov fuzzy process with a transition possibility measure and a general state space. Kostya E. Avrachinkov introduced the definition of general finite state fuzzy Markov chains, which will be compared with classical Markov chains based on probability theory.

In this paper, we designed the definition of possibility distribution function. Based on the definition of possibility distribution function introduced, the fuzzy Markov chain as a perception of usual Markov chain was framed. The multi step transition process obtained by using the possibility distribution function. Using this approach, we implement two state multistep transition processes and is calculated the age specific member rate. We designed fuzzy expert medical system and applied to the distribution and decision factors of respiratory diseases.

We collect the data for the commonly affecting Arthropod and Zoonoses diseases age wise, symptom wise and related host factors through expert survey and literature survey. From the data, we formed a fuzzy relation between disease-age groups and host-age groups. By using the fuzzy relation formed, the age specific member rate for the Arthropod and Zoonoses diseases was calculated. Finally, the calculated values were indexed [4, 5]. This rule based fuzzy expert system is rapid and economical compared to traditional active search systems. Comparison the results of the developed fuzzy expert system with the relevant literature was shown that the fuzzy expert system gives close result.

2. Basic Definitions

2.1. Definition (Possibility Distribution Function)

Let $\tilde{F}$ be a fuzzy set in a universe of discourse U, which is characterized by its membership function $\mu_{\tilde{F}}(u)$, which is interpreted as the compatibility of $u \in U$ with the concept labeled $\tilde{F}$. Let X be a variable taking values in U and $\tilde{F}$ act as a fuzzy restriction, $\tilde{R}(X)$, associated with X. Then the proposition " X is $\tilde{F}$", which translates into $\tilde{R}(X) = \tilde{F}$ associates a fuzzy event, $\tilde{\pi}$, with X which is postulated to be equal to $\tilde{R}(X)$. The possibility distribution function, $\pi_{\tilde{R}}(u)$, characterizing the fuzzy event $\tilde{\pi}$ is defined to be numerically equal to the membership function $\mu_{\tilde{F}}(u)$ of $\tilde{F}$, that is, $\tilde{\pi} \hat{=} \mu_{\tilde{F}}$, that is, $\tilde{\pi} \hat{=} \pi_{\tilde{R}}(u)$. The symbol $\hat{=}$ will always stand for "denotes" or "is defined to be".

2.2 Definition (Finite - Fuzzy Sets)

A (finite) fuzzy set (a fuzzy event, a fuzzy relation or a fuzzy restriction,..)$\tilde{\pi}$, on S, is characterized by possibility distribution function $\pi_{\tilde{R}}$,

$$\pi_{\tilde{R}} : S \to [0,1],$$

that takes on a finite number of possible fuzzy sets will be denoted by $\tilde{\pi} = \{\tilde{\pi}_n, n = 0, 2, \cdots\}$. The set of all fuzzy set on S is denoted by $\mathcal{F}(S)$.

Let $\{\tilde{\pi}_n, n = 0, 1, 2, \cdots\}$ be a sequence of random fuzzy sets (or a discrete fuzzy parameter stochastic process). Let the possible outcomes of $\tilde{\pi}_n$ be $\tilde{i}$ ($\tilde{i} = 0, 1, 2, \cdots$), where the number of outcomes may be finite (say, m) or denumerable. The possible values of $\tilde{\pi}_n$ constitute a set $S = \{0, 1, 2, \cdots\}$ and that the process has the fuzzy state space S. Unless otherwise stated, by fuzzy state space of a fuzzy Markov Chain, we shall imply discrete fuzzy state space (having a finite or a countably infinite number of elements); it could be $\mathcal{F}(S) = \{0, 1, 2, \cdots\}$.

2.3 Definition (Fuzzy Markov Chain)

The fuzzy stochastic process $\{\tilde{\pi}_n, n = 0, 1, 2, \cdots\}$ is called a fuzzy Markov Chain, if, for

$\tilde{i}, \tilde{j}, \tilde{i}_0, \tilde{i}_1, \cdots, \tilde{i}_{n-1} \in \mathcal{F}(S)$.

$$\begin{aligned}
&\pi_{\tilde{R}}\{x_{n+1} = \tilde{j} | x_n = \tilde{i}, x_{n-1} = \tilde{i}_{n-1}, \cdots, x_1 = \tilde{i}_1, x_0 = \tilde{i}_0\} \\
&\pi_{\tilde{R}}\{x_{n+1} = \tilde{j} | x_n = \tilde{i}\} \\
&\pi_{\tilde{i}\tilde{j}} \quad \text{(say)}
\end{aligned}$$

whenever the first member is defined.

3. Fuzzy Model

We take steps to calculate the age specific occurrence of some particular events. Due to lack of sufficient information and the existence of vague situations, the future state of the systems might not been known completely. In such occasions, we consider the fuzzy Markov Chain to model the phenomena [1]. The model proposed for the age specific prevalence will be studied by means of the conditional possibility distribution function given by

$$\pi_{\tilde{i}\tilde{j}}^{(n)} = \pi_{\tilde{R}}\{x_n = \tilde{j} | x_{n-1} = \tilde{i}\} \tag{1}$$

be the conditional possibility distribution function from fuzzy state $\tilde{i}$ to fuzzy state $\tilde{j}$ at time n. We have $\pi_{\tilde{i}\tilde{j}}$,

$$0 \leq \pi_{\tilde{i}\tilde{j}} \leq 1, \tilde{i}, \tilde{j} \geq 0, \sum_{j=0}^{\infty} \pi_{\tilde{i}\tilde{j}} = 1, \tilde{i} = 0, 1, 2, \cdots$$

Let $\prod$ denote the matrix of one-step transition possibility distribution function, $\pi_{\tilde{i}\tilde{j}}$, so that

$$\prod = \left\| \begin{matrix} \pi_{00} & \pi_{01} & \pi_{02} & \cdots \\ \pi_{10} & \pi_{11} & \pi_{12} & \cdots \\ \pi_{20} & \pi_{21} & \pi_{22} & \cdots \\ \vdots & \cdots & \vdots & \vdots \end{matrix} \right\|.$$

We now define the n step transition possibility distribution function $\pi_{\tilde{i}\tilde{j}}^{(n)}$ to be the possibility distribution function that process in fuzzy state $\tilde{i}$ will be in fuzzy state $\tilde{j}$ after n additional transitions, that is,

$$\pi_{\tilde{i}\tilde{j}}^{(n)} = \pi_{\tilde{R}}\{x_{n+m} = \tilde{j} | x_m = \tilde{i}\}, \quad n \geq 0, \tilde{i}, \tilde{j} \geq 0. \tag{2}$$

Of course $\pi^{(1)}_{\tilde{i}\tilde{j}} = \pi_{\tilde{i}\tilde{j}}$. Similarly,

$$\pi^{(n+m)}_{\tilde{i}\tilde{j}} = \sum_{\tilde{k}=0}^{n} \pi^{(n)}_{\tilde{i}\tilde{k}} \pi^{(m)}_{\tilde{k}\tilde{j}} \quad \text{for all} \quad n, m \geq 0, \quad \text{all} \quad \tilde{i}, \tilde{j}.$$

The multistep transition possibility-distribution function may be written in the matrix for

$$\prod^{(n)} = \begin{Vmatrix} \pi^{(n)}_{00} & \pi^{(n)}_{01} & \pi^{(n)}_{02} & \cdots \\ \pi^{(n)}_{10} & \pi^{(n)}_{11} & \pi^{(n)}_{12} & \cdots \\ \pi^{(n)}_{20} & \pi^{(n)}_{21} & \pi^{(n)}_{22} & \cdots \\ \vdots & \cdots & \vdots & \vdots \end{Vmatrix}.$$

Here we compute the multistep transition possibility-distribution matrix by using Fuzzy Chapman Kolmogorov equation, which will be compared with classical Chapman Kolmogorov equation based on probability theory.

If we let $\prod^{(n)}$ denote the matrix of n-step transition possibility distribution functions $\pi^{(n)}_{\tilde{i}\tilde{j}}$, then equation (2) assert that

$$\prod^{(n+m)} = \prod^{(n)} \cdot \prod^{(m)}$$

where the dot represents matrix multiplication. Hence, in particular,

$$\prod^{(2)} = \prod^{(i+1)} = \prod \cdot \prod = \prod^{2}$$

and by induction

$$\prod^{(n)} = \prod^{((n-1)+1)} = \prod^{n-1} \cdot \prod = \prod^{n}.$$

That is, the n-step transition matrix may be obtained by multiplying the matrix $\prod$ by itself n-times. So far, all of the possibilities we have considered are conditional possibilities. For instance, $\prod^{(n)}_{\tilde{i}\tilde{j}}$ is the possibility that the fuzzy state at time n is $\tilde{j}$ given that the initial fuzzy state at time 0 is $\tilde{i}$. If the unconditional distribution of the fuzzy state at time n is desired, it is necessary to specify the possibility distribution of the initial fuzzy state. Let us denote this by

$$\pi_{\tilde{i}}(x_0) = \pi_{\tilde{R}}\{x_0 = \tilde{i}\}, \ \tilde{i} \geq 0, \quad (0 \leq \pi_{\tilde{i}}(x_0) \leq 1).$$

All unconditional possibilities may be computed by conditioning on the initial fuzzy state. That is,

$$\begin{aligned}
\pi_{\tilde{R}}\{x_n = \tilde{j}\} &= \pi_{\tilde{j}}(x_n) \\
&= \sum_{\tilde{i}}^{\infty} \pi\{x_n = \tilde{j} | x_0 = \tilde{i}\}\pi\{x_0 = \tilde{i}\} \\
&= \sum_{\tilde{i}}^{\infty} \pi_{\tilde{i}\tilde{j}}^{(n)}(x)\pi_{\tilde{i}}(x_0)
\end{aligned}$$

Let we assume that $\tilde{i} = \tilde{j}$, then

$$\pi_{\tilde{i}\tilde{i}} = \pi_{\tilde{i}}(x_n)/\pi_{\tilde{i}}(x_0), \quad \tilde{i} = 0, 1, 2, \cdots$$

It can be written as

$$\pi_{\tilde{i}\tilde{i}}^{(n)}(x_i) = \prod_{k=t}^{t+n-1} \pi_{\tilde{i}\tilde{i}}(x_k) = \pi_{\tilde{i}}(x_{t+n-1})/\pi_{\tilde{i}}(x_{t-1}).$$

So, the multistep transition process can be obtained by $\pi_{\tilde{R}}(x)$.

3.1 Method of Calculation of Age-specific Member Rate (ASMR)

By using the above process, we consider two fuzzy states such as occurrence $(x_t| = 1)$ and non-occurrence $(x_t = 0)$. The transition possibility distribution functions of fuzzy Markov process in a 2 matrix:

$$\prod = \begin{Vmatrix} \pi_{00} & \pi_{01} \\ \pi_{10} & \pi_{11} \end{Vmatrix}.$$

All elements in matrix $\prod$ are non-negative numbers, and $\sum_{\tilde{j}=0}^{\infty} \pi_{\tilde{i}\tilde{j}} = 1, \tilde{i} = 0, 1$. For occurred value not re-occurred, we get $\pi_{10} = 0, \pi_{11} = 1$ for $\pi_{01}(t) = 1\pi_{00} \cdot \pi_{00}(t)$ given by

$$\pi_{00}(t) = \pi_{\not\subset\tilde{R}}\{x_t | x_{t-1}\} = \pi_{\not\subset\tilde{R}}(x_t)/\pi_{\not\subset\tilde{R}}(x_{t-1}).$$

Thus the n-step transition process can be written as

$$\pi_{00}^{(n)}(t) = \prod_{k=t}^{t+n-1} \pi_{00}(k) = \prod_{\not\subset\tilde{R}}(x_{t+n-1})/\prod_{\not\subset\tilde{R}}(x_{t-1}.$$

From the original data of the age distribution, multistep transition process is calculated. Here t is the state of age group, and we get the new age-specific member rate (ASMR) between the age group t to $t+n$ is given by

$$(ASMR)_t = 100\pi_{\not\subset\tilde{R}}(x_t)\pi_{01}^{(n)}(t) = \frac{100\pi_{\not\subset\tilde{R}}(x_t)(\pi_{\not\subset\tilde{R}}(x_{t-1}) - \pi_{\not\subset\tilde{R}}(x_{t+n-1}))}{\pi_{\not\subset\tilde{R}}(x_{t-1})}.$$

4. Fuzzy Expert System Designing

Expert system in medicine consists of medical expert and fuzzy system [3]. We apply the fuzzy expert system in medical diagnosis. Fuzzy expert systems and various intelligent techniques help for classification. The following classifications are related to medical diagnosis: symptoms and findings, the medical knowledge, disease and diagnosis, diseases and observable phenomena.

We use the following symbols to sketch the above classification.

$$\begin{aligned}
\tilde{S} &= (\tilde{s}_1, \cdots, \tilde{s}_m): \quad \text{set of symptoms.}\\
\tilde{D} &= (\tilde{d}_1, \cdots, \tilde{d}_n): \quad \text{set of diseases.}\\
\tilde{O} &= (\tilde{o}_1, \cdots, \tilde{o}_p): \quad \text{set of observable phenomena.}\\
\tilde{T} &= (\tilde{t}_1, \cdots, \tilde{t}_q): \quad \text{set of age groups.}
\end{aligned}$$

All $\tilde{s}_i, \tilde{d}_j, \tilde{o}_k, \tilde{t}_l$ are fuzzy sets characterized by their respective membership values. The membership values of these relationships $\tilde{T}, \tilde{S}], [\tilde{S}, \tilde{D}]$ and $[\tilde{D}, \tilde{O}]$ converted into fuzzy relation $[\tilde{R}_1, \tilde{R}_2, \tilde{R}_3]$ are mentioned in two aspects.

(i) Occurrence of $\tilde{s}_i$ in case $\tilde{d}_j$ (infected- $\tilde{I}_1, \tilde{I}_2$),

(ii) Non-occurrence of $\tilde{s}_i$ in case $\tilde{d}_j$ (uninfected - $\tilde{U}_1, \tilde{U}_2$).

This leads to the definition of fuzzy relation. The membership functions for these two fuzzy states are defined to be

$$\begin{aligned}
\mu_{\tilde{I}}(x) &= \max_{s\ U_1}(y), \mu_{\tilde{S}}\{\min(\mu_{\tilde{I}_1}, \mu_{\tilde{I}_2}(x))\}, \quad x \in X \times X\\
\mu_{\tilde{U}}(y) &= \max_{s\in S}\{\min(\mu_{\tilde{U}_1}(y), \mu_{\tilde{U}_2}(y))\}, \quad y \in Y \times Y.
\end{aligned}$$

The $\tilde{s}_i, \tilde{d}_j$ occurrence relationships are acquired empirically from medical experts using the membership values. Other relationships such as age\symptom, symptom\disease,

disease\observable phenomena are also defined as fuzzy sets. Possibility interpretations of relations (max-min) are used. Given an agegroup\disease relationships and the observable phenomena\age-group relationships yield fuzzy diagnostic indications that are basis for establishing occurrence and nonoccurrence diagnosis. Finally, two different relations are calculated by means of fuzzy relation (fuzzy composition).

$$\tilde{I} = \tilde{I}_1 \circ \tilde{I}_2 = \{(x, \max_{s \in S}\{\min(\mu_{\tilde{I}_1}(x))\}, \mu_{\tilde{I}_2}(x))\} | x \in X \times X\}$$

$$\tilde{U} = \tilde{U}_1 \circ \tilde{U}_2 = \{(y, \max_{s \in S}\{\min(\mu_{\tilde{U}_1}(y), \mu_{\tilde{U}_2}(y))\} | y \in Y \times Y\}$$

To calculate the age specific member rate for the above fuzzy sets, we use the following formulas.

$$R_t(\tilde{I}) = \frac{100\mu_{\not\subset \tilde{I}}(x_t)(\mu_{\not\subset \tilde{I}}(x_{t-1}) - \mu_{\not\subset \tilde{I}}(x_{t+n-1}))}{\mu_{\not\subset \tilde{I}}(x_{t-1})}$$

$$R_t(\tilde{U}) = \frac{100\mu_{\not\subset \tilde{U}}(y_t)(\mu_{\not\subset \tilde{U}}(y_{t-1}) - \mu_{\not\subset \tilde{U}}(y_{t+n-1}))}{\mu_{\not\subset \tilde{U}}(y_{t-1})}$$

5. Application of Arthropod and Zoonoses Diseases

Applying the fuzzy expert system to Arthropod and Zoonoses diseases is compound of expert and fuzzy system. It is known as hybrid system. This system consists of expert individual, fuzzy rule base, max-min principle, fuzzification and defuzzification. Modern epidemiology is concerned with the identification of risk groups of larger groups. It helps to define priorities and points to those most in need of attention [2]. Infections of the Arthropod and Zoonoses tract are the most common human ailment caused by both bacteria and viruses. While they are a source of discomfort, disability and loss of time for most adults, they are substantial cause of unhealthy and death in young children and the elderly. The data for the developed system were taken from the literature and with the help of medical experts. Firstly, the databases for different types of Arthropod and Zoonoses infections have been prepared [2]. We consider the following set of common disease $\tilde{D}$ as follows:

$\tilde{d}_1$-dengue; $\tilde{d}_2$- malaria; $\tilde{d}_3$ - filaria; $\tilde{d}_4$ - yellow feve; $\tilde{d}_5$ - Japanese encephalitis.

The experienced medical experts have taken the symptom data for the diseases age wise. We consider the following set $\tilde{S}$ of common symptoms:

$\tilde{s}_1$- vomiting; $\tilde{s}_2$- fever; $\tilde{s}_3$- epistaxis; $\tilde{s}_4$- chills; $\tilde{s}_5$- nausea; $\tilde{s}_6$- sore throat; $\tilde{s}_7$- head ache; $\tilde{s}_8$- muscular pain; $\tilde{s}_9$- malaise; $\tilde{s}_10$- lymphadenopathy.
We consider the following set $\tilde{H}$ of host factors for those diseases:
$\tilde{h}_1$- race; $\tilde{h}_2$- immunity; $\tilde{h}_3$- chronic illness; $\tilde{h}_4$- housing; $\tilde{h}_5$ -climate; $\tilde{h}_6$ - insanitation; $\tilde{h}_7$- occupation; $\tilde{h}_8$- attitudes; $\tilde{h}_9$- lifestyle; $\tilde{h}_10$ - socio economic conditions.
We are consider the following $\tilde{T}$ of common age group $v\tilde{T} = (\tilde{t}_0, \tilde{t}_1, \cdots, \tilde{t}_7)$. The membership values of these relationships $[\tilde{T}, \tilde{S}], [\tilde{S}, \tilde{D}]$ and $[\tilde{D}, \tilde{H}]$ are converted into fuzzy relations and three matrices have been formed. The three matrices are

Age, symptom confirmation relationship-matrix, $[\tilde{R}_1]$

Symptom, disease confirmation relationship-matrix, $[\tilde{R}_2]$

Disease, host factor confirmation relationship-matrix, $\tilde{R}_3]$.

Then the computation of max-min composition $\tilde{R}_4 = \tilde{R}_0 \circ \tilde{R}_2$ is assumed to describe the state of patient (age-wise) in terms of diagnosis as a fuzzy subset $\tilde{R}_4$ of $\tilde{T} \times \tilde{D}$ characterized by its membership function

$$\mu_{\tilde{R}_4}(t, d) = \max_{s \in S}\{\min(\mu_{\tilde{R}_1}(t, s), \mu_{\tilde{R}_2}(s, d))\}, (t, d) \in \tilde{T} \times \tilde{D}.$$

The max-min composition $\tilde{R}_4$ max-min $\tilde{R}_3$ is then the fuzzy set

$$\tilde{R}_5 = \tilde{R}_4 \circ \tilde{R}_3 = \left\{(t, h), \mu_{d \in D}\{\min(\mu_{\tilde{R}_4}(t, d), \mu_{\tilde{R}_3}(d, h)\})|(t, h) \in \tilde{T} \times \tilde{H}\right\}.$$

The possibility distribution function of the complement of fuzzy set $\tilde{R}_4, \pi_{\not\subset \tilde{R}_4}(t, d)$ is denoted by $\pi_{\not\subset \tilde{R}_4}(t, d) = 1 - \pi_{\tilde{R}_4}(t, d)$. Similarly, the possibility distribution function of the complement of the fuzzy set $\tilde{R}_5 = \tilde{R}_4 \circ \tilde{R}_3, \pi_{\not\subset \tilde{R}_5}(t, h)$ is denoted by $\pi_{\not\subset \tilde{R}_5}(t, h) = 1 - \pi_{\tilde{R}_5}(t, h)$. From $\not\subset \tilde{R}_4$, the fuzzy Markov risk rate (FMRR) is set up as a new measure of infection risk. It varies as the product of proportion of possible susceptible at a given age t, which the possibility of becoming infected in two age/time steps, $\pi^{(2)}_{\tilde{U}\tilde{I}}(t, d)$. It is calculated formula

$$FMRR(\tilde{T}, \tilde{D}) = 100\pi_{\not\subset \tilde{R}_4}(t, d)\pi^{(2)}_{\tilde{U}\tilde{I}}(t, d)$$

where

$$\pi^{(2)}_{\tilde{U},\tilde{I}}(t, d) = \pi_{\not\subset \tilde{R}_4}(t-1, d) - \pi_{\not\subset \tilde{R}_4}(t+1, d)/\pi_{\not\subset \tilde{R}_4}(t-1, d), t \in \tilde{T}, d \in \tilde{D}.$$

As such from $\not\subset \tilde{R}_5$, the fuzzy Markov risk rate of host factor formula is

$$FMRR(\tilde{T}, \tilde{H}) = 100\pi_{\not\subset \tilde{R}_4}(t, h)\pi^{(2)}_{\tilde{U}\tilde{I}}(t, h)$$

where

$$\pi^{(2)}_{\tilde{U}\tilde{I}}(t,h) = \pi_{\not\subset \tilde{R}_4}(t-1,h) - \pi_{\not\subset \tilde{R}_4}(t+1,h)/\pi_{\not\subset \tilde{R}_4}(t-1,h), t \in \tilde{T}, h \in \tilde{H}.$$

Thus, the fuzzy Markov chain model can give precise and reliable information for different age-specific prevalence and its related factors.

Table (1): $[\tilde{R}_1]$

Age (T)	Symptom	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Born	(t0)	0	0	0	0	0	0	0	0	0	0
1-10	(t1)	.6	.3	.5	.5	.4	.6	.4	.5	.4	.5
11-20	(t2)	.1	.1	.2	.3	.1	.3	0	0	.1	.2
21-30	(t3)	.3	.1	.3	.3	.3	.4	.2	.1	.2	.4
31-40	(t4)	.4	.2	.4	.4	.3	.5	.3	.3	.3	.4
41-50	(t5)	.5	.3	.4	.4	.4	.5	.4	.4	.3	.5
51-60	(t6)	.1	.1	.3	.3	.2	.4	.2	.1	.1	.3
Above 60	(t7)	.6	.4	.6	.6	.5	.6	.5	.5	.5	.6

Table (2): $[\tilde{R}_2]$

Symptom \ Disease	d1	d2	d3	d4	d5
S1	.9	.7	.8	.7	.7
S2	.7	0	.7	0	0
S3	0	0	.5	0	0
S4	.8	.9	.9	0	0
S5	0	0	0	0	0
S6	0	0	0	0	1
S7	1	0	1	0	0
S8	.8	0	.8	0	0
S9	0	0	0	1	0
S10	0	0	.8	0	0

Table (3): $[\tilde{R}_3]$

Disease \ Host factor	h1	h2	h3	h4	h5	h6	h7	h8	h9	h10
d1	.9	.8	1	.8	.7	0	0	0	0	0
d2	.7	.9	0	0	0	0	0	0	0	0
d3	.8	.9	1	.8	.7	.8	0	0	.5	0
d4	.7	0	0	0	0	0	0	0	0	1
d5	.7	0	0	0	0	0	1	0	0	0

Table (4)

	d1	d2	d3	d4	d5
t0	1	1	1	1	1
t1	.7	.7	.7	.9	.6
t2	.4	.4	.4	.4	.4
t3	.7	.7	.6	.9	.6
t4	.6	.6	.6	.6	.5
t5	.5	.5	.5	.5	.5
t6	.7	.7	.7	.9	.7
t7	.4	.4	.4	.4	.4

Table (5)

	h1	h2	h3	h4	h5	h6	h7	h8	h9	h10
t0	1	1	1	1	1	1	1	1	1	1
t1	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
t2	.7	.7	.7	.7	.7	.7	.7	.7	.7	.9
t3	.6	.6	.6	.6	.6	.6	.6	.6	.6	.9
t4	.5	.6	.6	.6	.6	.5	.5	.5	.5	.6
t5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
t6	.6	.7	.7	.7	.7	.6	.6	.6	.6	.9
t7	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4

Table (6)

FMRR $(\tilde{T}, \tilde{D})$	d1	d2	d3	d4	d5
t1	08.0	08.0	08.0	08.0	08.0
t2	21.0	21.0	21.0	09.0	28.0
t3	10.0	10.0	08.6	30.0	10.0
t4	17.1	17.1	10.0	27.0	08.3
t5	16.7	16.7	16.7	16.7	10.0
t6	00.0	00.0	10.0	00.0	08.6

Table (7)

FMRR $(\tilde{T}, \tilde{H})$	h1	h2	h3	h4	h5	h6	h7	h8	h9	h10
t1	08.00	08.00	08.00	08.00	08.00	08.00	08.00	08.00	08.00	08.00
t2	28.00	21.00	21.00	21.00	21.00	28.00	26.00	28.00	28.00	09.00
t3	10.00	08.57	08.57	08.57	08.57	10.00	10.00	10.00	10.00	30.00
t4	08.33	10.00	10.00	10.00	10.00	08.33	08.33	08.33	08.33	26.67
t5	10.00	16.67	16.67	16.67	16.67	10.00	10.00	10.00	10.00	16.67
t6	08.57	10.00	10.00	10.00	10.00	08.57	08.57	08.57	08.57	00.00

5.1. Results and Discussions

From the table 6, it is seen that,

- Arthropod and zoonoses diseases are mild in children than adults.
- The infection rate of d4 is higher among t3 and t4 age group.
- All the diseases are evenly distributed in t5 age group.
- A very high prevalence is noticed in t2 age group.

From the table 7, it is seen that,

- The influences of host factors are evenly distributed in all age groups.
- The host factors play a major role in determining the outcome of the disease in t2 age group.
- The association of the children with host factors shows high disease burden when compared to adults.

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