Disease Modelling for Impact Assessment for Disease Outbreaks

Modelling is the representation of physical processes designed to increase appreciation and understanding of them. It is the representation of events in quantitative mathematical terms, so that predictions can be made about the events.

Disease modelling involves construction of models in an attempt to predict pattern of disease occurrence and what is likely to happen if various alternative control techniques as well as increasing understanding of the life-cycles of infectious agents.

Computers can be used to simulate situations. A model can be utilized effectively only if it is sound. Affirmative answers to the following questions will help to ascertain the validity of the model:

1. Have all the known determinants that influence occurrence of diseases been included?
2. Can the value of these determinants be estimated with accuracy?
3. Does the model make biological “common sense”

Models are basically instruments for making predictions. They cannot stand alone in determining efficient control strategies, but should be used in conjunction with accurate field data and experimental techniques.

Emphasis will be placed on developing a conceptual understanding of the basic methods of modelling and on their practical application rather than the manipulation of mathematical equation.

Types of Models

Veterinary modelling has been directed towards infectious disease, although non-infectious ones can also be modelled.

Infectious agents can be classified into two groups according to their generation dynamics: microparasites (e.g. viruses and bacteria), and macroparasites (e.g. helminths, and arthoropods) and the two different dynamic patterns lend themselves to two different types of modelling.

Density models: consider the absolute number of infectious agents in each host and are commonly used in macroparasitic infections, where numbers of infectious agents can be estimated either in the host or in the environment.

Prevalence models: these are frequently employed in the studies of microparasitic infections and these consider the presence/absence of infections in various host cohorts e.g. young and mature, immune and susceptible.

The density model is potentially the more refined of the two techniques because it attempts to enumerate the number of infectious agents with which a host is challenged.

Deterministic/Stochastic Models

In many models, the values of input parameters can be fixed the results obtained do not take account of uncertainty (i.e. random variations). Such mathematical descriptions are examples of Deterministic models. In contrast, some other models describe process/events subject to random variation so that the outcomes occur with a probability. These models are stochastic. These often enable confidence intervals to be associated with the outputs.

Density and Prevalence models can be formulated deterministically or stochastically using three approaches classifying models:

1) Models using differential calculus
2) Models using simulation
3) Models using matrices and networks

Models using differential calculus

Differential calculus is a mathematical technique for finding small (theoretically infinitesimal) rates of change. Models based on this procedure generally establish equations in terms of rate of change of either the number of parasites, or the number of hosts, or subsets of these populations with respect to time.

Models using simulation

The goal of these models is *simulation* of the performance of parasites or diseases in relation to conditions which change either deterministically or stochastically. The power and success of simulation models have been closely linked to advances in computer technology. There are 3 main types of simulation models:

a) Empirical models
b) Explanatory models
c) Monte Carlo models

Empirical Models

These utilise indicators that are obtained by analysing the relationship between morbidity and any associated variables. Frequently used variables are those relating to climate. These models are not strictly mathematical models because they do not attempt to analyse the dynamics of agents` life-cycle but simply to quantify associated phenomena. E.g. fascioliasis. Considering the life-cycle of its intermediate host F hepatica in small ruminants, two important meteorological factors in the development of the parasite are temperature and the presence of water. These are the bases on which the simulation models are formed.

Nematodiriasis: whereby the life-cycle of Nematodiriasis *spp.* is temperature dependent. There is a correlation between soil temperature and larval hatching rates. The mean soil temperature at a particular time (month) is used to predict the date of maximum larval count on the pasture.

The two examples given are deterministic models because no consideration is given to random variation.

Explanatory models using simulation

These are mathematical models that describe the dynamics of parasite and host population. These techniques allow the course of disease to be simulated. They include models for forcasting fluke morbidity, the air-borne spread of FMD and the occurrence of clinical ostertagiasis.

Bovine ostertagiasis: the level of pasture contamination by infective O ostertagi level can be predicted by simulating the course of events experienced by various factors associated with the parasite eggs deposited on pasture. These include the developmental stages of the eggs (L_1 – L_3), infectivity, fecundity and migratory behaviour of the larva. A prediction of herbage infective larval burdens using this type of simulation model can facilitate optimum use of antihelminthics and movement of animals to safe pasture before challenge by large numbers of infective larvae, thereby preventing clinical ostertagiasis. Similar approach has been successfully applied to tick infestation in sheep.

Monte Carlo methods

Simulation model whereby random processes are simulated using random numbers in order to decide whether or not event takes place. This is somewhat similar to gambling hence the term "Monte Carlo"simulation. E.g. sheep tick control.

Modelling using Matrices and networks

Matrix and network methods are similar and often the same problem can be formulated using a network and matrix approach. The network formulation is particularly attractive when time delays are a feature of the life-cycle being modelled and when the output response of a biological system is to be measured for a given input.

Matrix formulations on the other hand are attractive when the behaviour of several states of a population is of interest at successive points in time. Matrices often take the form of a rectangular array containing numbers of hosts/parasites in a defined state or stage of development known as the <u>state vector</u> or containing reproduction and survival rates of hosts or parasites in different states or stages known as transition matrix. In this way, it is possible to obtain the state of the system from one point in time to another.

Further Veterinary Applications of Modelling

Models have been developed for the choice of disease control strategies; e.g. for Brucellosis in the UK and USA. Models have also been used to investigate diseases of uncertain aetiology such as Epizootic Bovine Abortion, to model genetic resistance and antigenic drift and to study resistance to anthelminthics and acaricides and the value of identification and recording systems in the control of contagious diseases.

Models that access the cost of disease and its control have also been designed.

As earlier mentioned, it is important to note that modelling in Veterinary Medicine which is also a component of epidemiological approach, cannot be effectively used without reliable field and experimentally derived data relating to diseases` natural host. When use in association with the above, modelling is a valuable aid to an increased understanding of diseases.

DATABASE APPLICATIONS IN KEEPING OF DIAGNOSTIC AND CLINICAL RECORDS

The advent of the new generation of powerful but robust and inexpensive computers means that Veterinary practitioners now have ample facilities to collate, enter, check, analyze and store vast amount of qualitative data on animal health, production and administrative responsibilities as well as generating reports in the format required for end-users in order to aid management decision making.

Areas of computer application in Veterinary practice can be summarized as follows:

1) Record keeping involving
   a) Clinic

b) Epidemiological data

c) Farm records

d) Abattoir records

2) Laboratory diagnosis
3) Surgery
4) Pharmacy
5) Interaction and learning
6) Entertainment

General Application

There are several areas where computers should be effective in a good and progressive modern Veterinary practice and these include:

- Fee sensitivity elimination
- Perception of value
- Estimating System
- Information generation
    - *Management data*
    - *Medical Data*
- Perception of personal caring
- Organisational systems
- Veterinary Education
- International Veterinary Information Centre (IVIC)
- Research
- Communication
- On-line prescription

Management of Accounts by Use of Spreadsheet

An electronic spreadsheet is a productivity software package that enables the user to create tables and especially financial schedules quickly by entering labels and values into cells on a display screen grid to easily manipulate the numerical data. This is similar to ledger pages divided into columns and rows (called spreadsheets). Businesses have traditionally used spreadsheets to keep track of their financial transactions.

Applications of Spreadsheets

Several electronic spreadsheets have been produced, these include Lotus 1-2-3, Quattro Pro and the most recent and very versatile; Microsoft Excel from Microsoft Inc.

Excel Spreadsheet

This is a program with which one can view, organize, analyze and share data. The software is very user friendly that allows direct data inputting and importation of data from other applications in order to perform calculations and generate charts/graphs.

Excel uses workbooks and worksheets to record data and do quick calculations.

Database

This refers to tables made of labelled columns that contain specific kind of data e.g. name, age etc. in rows that contain a piece of data from each column.

The Worksheet

This is divided into columns and rows. Each column is identified by letters A – Z, then AA – AZ, BA – BZ etc., which appears in the top border and each row by a number which appears in the left border of the worksheet. The intersection of a specific column and row creates a cell. A cell is a unit of the worksheet that stores data.

Cells are identified by addresses, e.g. the cell in column B row 10 is referred to as cell B10. The number of rows and columns vary among the different spreadsheets. An excel worksheet contains up to 65,536 rows and 260 columns. A workbook is a group of worksheets saved together as a single excel file. When a workbook is saved, all changes made to the worksheet in the workbook are also saved.

In Veterinary practice, a spreadsheet can be used in preparing financial planning e.g. budgets, preparing payrolls of staff, keeping track of revenues and expenditures (cash flow analysis) and keeping tracks of drugs in the pharmacy.

***Prepared by* Professor Morenike A. Dipeolu**
***With inputs from* Dr Z. Hassan**