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Differential Equation in Modelling of HAIs

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Abstract: We consider the SIR model related to HAI using a differential equation with differential mortality and constant population.
Keyword: Differential equation, Ordinary Differential Equation, SIR model.

I. INTRODUCTION

A differential equation is an equation with a function and one or more of its derivatives. The rate of change of a function at a point is defined at a point is defined by its derivatives. Differential equations have a variety of uses in daily life. It involves the derivative of a function or a dependent variable with respect to an independent variable. Population growth, spring vibration, heat flow, and radioactive decay can be represented using differential equations that have already been proven a significant part of applied and pure mathematics. A differential equation states how a rate of change ("a differential") in one variable is related to other variables.

II. ORDINARY DIFFERENTIAL EQUATION

An ordinary differential equation is a type of differential equation containing one or more functions of one independent variable and the derivatives of those functions. Ordinary differential equations appear in many different contexts, that includes mechanics, astronomy, geometry, and population modelling. It is used to calculate the movement or flow of electricity, the motion of an object to and fro like a pendulum, to explain thermodynamics concepts. Also, in medical terms, they are used to check the growth of the disease in graphical representation.

III. HOSPITAL ACQUIRED INFECTIONS (HAI)

Hospital Acquired Infections (HAI) are infections that occur while receiving health care, developed in a hospital or other healthcare facility that first appear 48 hours or more after hospital admissions or within 30 days after having received health care; multiple studies indicate that the common types of adverse drug events, HAI's, and surgical complications.

IV. STANDARDIZED INFECTION RATIO (SIR)

The Standardized Infection Ratio (SIR) is a statistic used to track HAIs over time. The SIR compares the actual number of HAIs at each hospital to predict the number of infections. The SIR model has the combination of three ordinary differential equations. The SIR model is used to model epidemics of infectious diseases. In SIR, the population exposed to infection is divided into three categories (i. e) as, Susceptible(S), Infected (I), and Recovered(R) creates a SIR model.

V. DIFFERENTIAL EQUATION IN HAI

The process of describing real-life complications by using a mathematical formulation is called the mathematical model. The mathematical modeling of infectious diseases was initiated by Bernoulli in 1760.The work of
Kermack and Mckendrick, published in 1927, had a major influence on the modelling framework. Their SIR model is still used to model epidemics of infectious diseases. The SIR model for the spread of infectious disease is a very simple model.
In this study, the acquisition of HAIs carries a significant increase in the mortality and morbidity of the total population (T) obtained through the differential equation and SIR model. The DE value provides the data to predict the approximate rate of mortality and morbidity of the total population.

1) Consider a population p = p(t) with constant relative birth and death rates α and β respectively, and a constant emigration rate m, where α, β and m are positive constants. Assume that modeled by the differential equation.

$$\frac{dp}{dt} = kp - m, \qquad \text{Where } k = \alpha - \beta$$

The solution of this equation that satisfies the initial condition P(o) = P_0.

We have $\frac{dp}{dt} = kp - m$

$\frac{dp}{dt} = k(p - \frac{m}{k})$

Let p - $\frac{m}{k}$ = x, Where P(o) = P_ox(0) = x_0
= $P_o \frac{m}{k}$

So, we have initial value problem.
$\frac{dx}{dt}$ = kx, x(0) = $P_o - \frac{m}{k}$

Solution of this problem is x(t) = $x_o e^{kt}$
P(t) - $\frac{m}{k}$ = $(P_0 - \frac{m}{k})e^{kt}$

P(t) = $\frac{m}{k} + \left(P_o - \frac{m}{k}\right)e^{kt}$

The condition on m will lead to an exponential expansion of the population.
Population will expand exponential.
When,

$$\frac{dp}{dt} > 0$$

$$k\,(P - \frac{m}{k}) > 0$$

At P(0) = P_0

$$k(\,P_0 - \frac{m}{k}) > 0$$

$$P_0 > \frac{m}{k}$$

$$m < kP_0$$

The condition on m will result in a constant population.
If population decline,

Population remains constant.
When,

$$\frac{dp}{dt} = 0$$

$$k\,(\,P - \frac{m}{k}) = 0$$

At P(0) = P_0

$$k\,(P_0 - \frac{m}{k}) = 0$$

VI. CONCLUSION

The main aim of the study is to know the SIR method related to HAI with the help of a Differential Equation. Mathematical modelling and differential equations are effective tools for dealing with the patterns of disease outbreaks. They provide us with useful production in the context of the impact of intervention in increasing or decreasing the number of infected susceptible.

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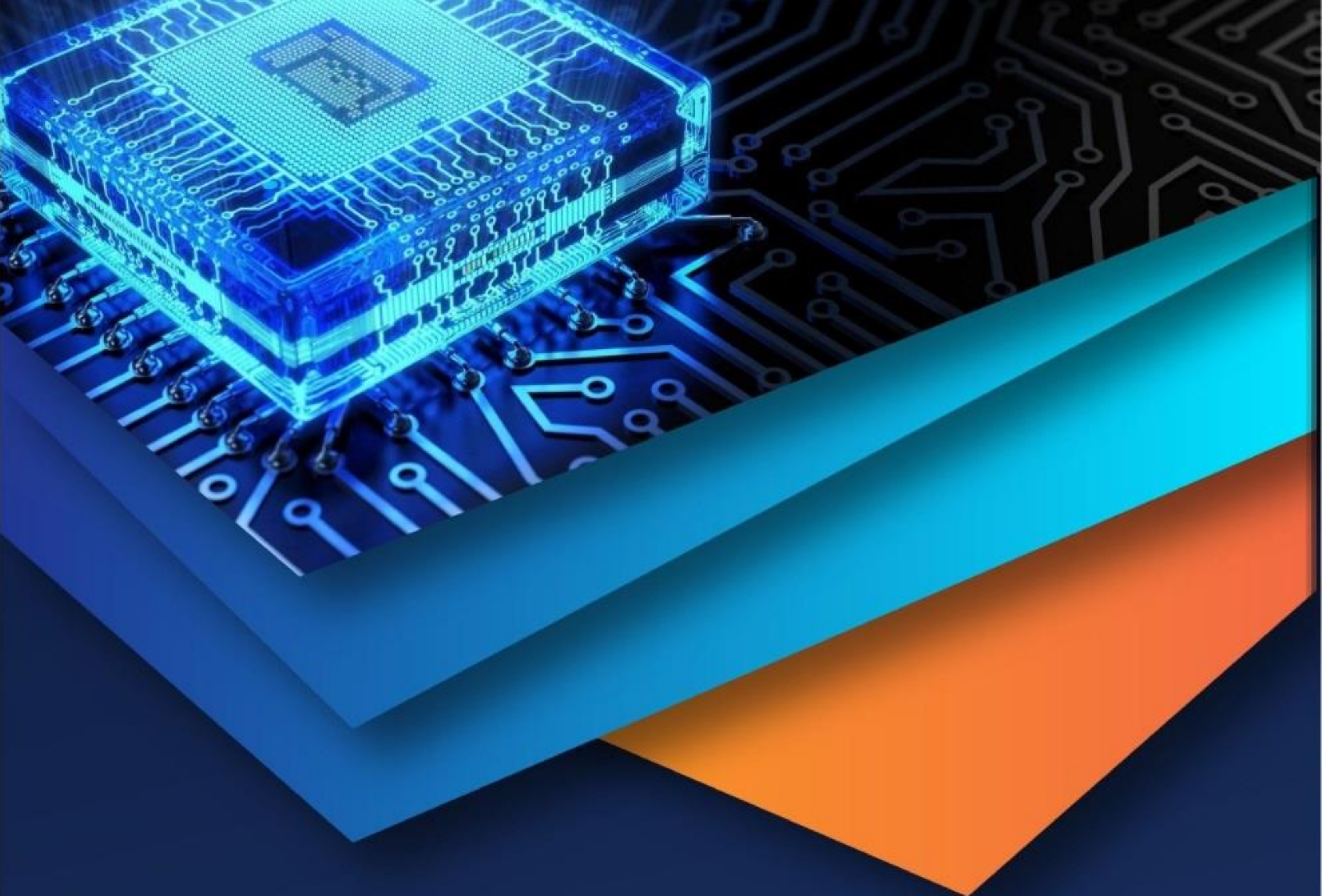

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