The Design of Diabetes Simulation System using Multi-Agent

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Abstract

Objectives of this research were 1) to design Diabetics Simulation Model, 2) to explore life style behavior of patients who suffer with diabetic, and 3) to develop diabetes simulation software. Research methodology applied consisted of 3 steps: to study life style of those who suffer with diabetic by using questionnaire confirming the risk of diabetics in metabolic group of population of 13,334 peoples in 2010, to design an equation to predict the risk by using case-control study technique, and to develop a behavior simulation program by using multi-agent. Research results of survey population from Mueang Nakhon Ratrasima District, Nakhon Ratrasima Province, indicated that causes of having diabetics can be divided into 3 categories: lack of exercise, obesity, inappropriate consumption behavior. Statistics reveals that the behavior that causes diabetic most is lack of exercise, which is accounted for 51 percent of total survey population. The probability of patients having diabetics is 0.61 of risky population and probability of anti-diseased is 0.64. The probability was utilized in the development of a computer program using Netlogo Software in order to simulate diabetes situation. The program can adjust different agents such as number of population, probability of being patient, probability of being anti disease, as well as determining an ideal time to manage the spread of the disease.

Keywords: Diabetes; Simulation; Multi-Agent;

1. Introduction

Thai people have greater risk of having diabetes because of context of economic and social changes in lifestyles with the lack of sense of sufficiency. People who do not conduct a physical check-up, and check their weight and sugar in the blood regularly may have diabetes. Patients who have high sugar in the blood for a long time, there may be complications to the other parts of the body such as eyes, heart, kidneys, nerves and blood vessels. Diabetes causes damage to the economy and health, which are considered as the top priority in the country. Government budgets for treat and public relations of diabetes have been increased. Based on 2005 and 2009 statistics, rate of diabetics patients in Thailand has increased for 611, 689, 795 and 845 per hundred thousand population respectively, [1] Number of patient.

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tend to raise every year, and it shows that government’s plans and strategies are not sufficient to solve the problem and to educate the population to be aware of the threat of this disease. This research focuses on how to design the prevalence of patients using the simulation system by survey population who are exposed to factor associated with diabetes and to develop an predictive equation’s agent to simulate the situation using NetLogo Software.

2. Knowledge Concerning to Diabetes

The study found that diabetes is divided into two categories: diabetics caused by genetic, and diabetics caused by lifestyle habits. As the cause of the first category diabetics is uncontrollable, therefore, the study about this disease focuses on lifestyle factors, as follows.[2]

- Exercise refers to exercise less than three times per week in each time is between 30 to 45 minutes.
- Obesity refers to people with a body mass index of more than 25 kg/m² and waistline more than 90 cm for a male and greater than 80 cm for female.
- Consumption refers to people who like to consume sweet and fat foods regularly.

3. Research Methodology

Simulation is a technique used to emulate the behavior of the system by applying computer programs. [3] Thus, this research was divided into three steps to as follows.

3.1. Population Survey

To survey information from population in order to be used as a default behavior of the simulation, such as rate of population who is risky to have diabetic by using Odds Ratio value of Case-Control Study Technique [4] and calculate probability of disease that are exposure or non-exposure factors from equations to below.

\[
\text{Odds Ratio (OR)} = \frac{AD}{BC} \quad (1)
\]

A is a number of patients exposed to the disease.
B is a number of healthy exposed to the diabetes.
C is a number of patients unexposed to the disease.
D is a number of healthy unexposed to the disease.

If all Odds Ratio values are more than 1.00, we can calculate the probability of being a patient by below equation:

\[
P_{\text{a}} = \frac{OR}{OR+1} \quad (2)
\]

If Odds Ratio value is less than 1.00, it refers to those who are anti-diseased or not exposed factor, therefore we can use those values as probability of anti-diseased.

3.2. Design Predictive Equation

To predict the disease is to design a linear equation using Monte Carlo technique [5] of random value from the probability of odds ratio value. The Linear equations are divided into two types, as per below.

- Number of patients refers those who are exposed to the factor and computer is used to randomize value is between 0 to probability value.
Anti-Disease refers those who are unexposed to the factor or defined as those who received treatment from a government to reduce the risk of disease by using random value between 0 to probability value, as illustrated in Table 1.

Table 1. Random from Probability

<table>
<thead>
<tr>
<th>Status of Population</th>
<th>Random Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diseased or Anti-Diseased</td>
<td>0 - P₀</td>
</tr>
<tr>
<td>Not diseased or not Anti-Diseased</td>
<td>&gt;P₀ - 1.00</td>
</tr>
</tbody>
</table>

According to differential efficiency with respect to time, the equation is as below. [6]

\[
\frac{dP}{dt} \left( \frac{\Delta P}{\Delta t} \right) = \frac{dP}{dt}
\]

\[
\frac{dP}{dt} \quad \text{is demographic changes per times.}
\]

Therefore, the equation becomes:

\[
P_{t+1} = P_t + \Delta t(RTG)
\]

\[
P_t \quad \text{is the number of population at the study time} \ t
\]

\[
P_{t+1} \quad \text{is the number of population at the study time} \ t + 1 \ \text{or next time period}
\]

\[
RTG \quad \text{is number of people who are diseased or anti-diseased derived from randomization}
\]

3.3. Software Development

NetLogo Software is utilized in this research in order to design the simulation, which is a multi-agent programmable modeling environment, as below table.

Table 2: Event Table

<table>
<thead>
<tr>
<th>Event Trigger Source</th>
<th>Activity Source</th>
<th>Response Activity Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>population change to diseased population exposed to factor population exposed to factor increased population who were exposed to factor population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>population change to diseased the population is inevitable from factor population inevitable from factor increased population who were inevitable from factor population</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus Table 3, design program, is divided into two parts: area of agents and rules of gents.

• The area of agents is divided into three agents: healthy agent is represented as blue man, diabetes agent is represented as red man and anti-diseased is represented as green man, as per below figure:
Rule of agents refers to change of population from being healthy to diabetes or to anti-diseased by using the algorithms of each agent as follow:

**Rule of Healthy to Diabetes Condition:** IF $R_{\text{random-Float}}$ 1.00 < Probability-of-Patients

**Action:** THEN Healthy change to Diabetes

**Rule of Healthy to Anti-Diseased Condition:** IF $R_{\text{random-Float}}$ 1.00 < Probability-of-Anti-Diseased

**Action:** THEN Healthy change to Anti-Diseased

### 4. Result of Research

#### 4.1. Population Survey

The survey of 13,334 peoples of population that were treated in Fort Suranari Hospital in 2010 and selected representative sample of 734 patients to be analyzed by using a Case-Control Study revealed following result:

<table>
<thead>
<tr>
<th>Exposure Factors.</th>
<th>Percent of People</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise</td>
<td>51</td>
<td>1.65</td>
</tr>
<tr>
<td>Obesity</td>
<td>4</td>
<td>1.32</td>
</tr>
<tr>
<td>Consumption</td>
<td>4</td>
<td>1.12</td>
</tr>
<tr>
<td>Exercise and Obesity</td>
<td>7</td>
<td>1.11</td>
</tr>
<tr>
<td>Exercise and Consumption</td>
<td>17</td>
<td>1.93</td>
</tr>
<tr>
<td>Obesity and Consumption</td>
<td>1</td>
<td>1.13</td>
</tr>
<tr>
<td>Exercise, Obesity and Consumption</td>
<td>3</td>
<td>1.31</td>
</tr>
</tbody>
</table>

According to Table 3, it is found that the most of the disease caused by lack of exercise, which is accounted for 51 percent of total study population, and followed by lack of exercise and in appropriate food consumption, which is accounted for 17 percent of total study population. In addition, the entire odds ratio of higher than 1.00 indicated that all factors give effect to the spread of the disease, when population’s life style are exposed to these factors.

<table>
<thead>
<tr>
<th>Probability</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>0.61</td>
</tr>
<tr>
<td>Anti-Diseased</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Table 4 presents result of Cast-Control Study. Probability of disease equals to 0.61, which means the population is exposed to factor; their risk of having the disease equals to 0.61 time of total population. In opposite, the probability of being anti-diseased equals to 0.64, which means the population is not exposed to factor, their risk of having the disease is less than others who are exposed to the factor equals to 0.64 of total population. In additional, the number of those who are risk to have this disease according to a survey conducted by Nakhon Ratchsima Provincial Public Health Office, in which the author has searched for information from information system database used for the management of Nakhon Ratchsima Provincial
Public Health Office, it is found that in 2010, number of population in Mueang Nakhon Ratchasima District who are risk to have diabetic was 445 people per months.

4.2. Experiment Software

Figure 2 represents an experiment to create a simulation by determining risk population agent value of 10,000 peoples and probability of anti diseased of 0.64, the government has a project to provide treatment for risked population of 445 peoples per month, probability of diabetes of 0.61, and risked population of 445 peoples per month. Experimental results revealed that when the time gone by until the 10th month, number of patient decreased gradually. The patient agent has decreased as population has been treated to be safe from the diseased. Therefore, if the government tries to add number of population to be treated, time and number of patient will be decreased accordingly, and we can set the program to be adjusted to the possibility of a treatment in accordance with the plans and programs of government properly.

5. Conclusion

Simulation Design by using Netlogo Software, which can be developed by studying behavior of those are exposed the factor causing the disease. In term of patient agent, case-control study was used to analyze the odd ratios of those who are risk to have diabetes or those who are anti-disease because of avoiding to be exposed to the risky factors and then it was applied for creating a probability table to randomly predict the number of patient per month. The program could create a simulation by adjusting patient agent and anti-diseased agent in order to observe the event, and result of events which could help to understand the characteristic of diabetics patient, and to try to avoid exposing to factors causing the disease such as exercise, control obesity or appropriate food consumption. The experimental results revealed that effective planning time will help inhibiting diabetics. For future studies, there should be a study on other factors effecting to the outbreak of diseases such as the increase rate of the genetic patient, and plans and strategies of government which have been implemented in order to reduce disease outbreak in order to develop a higher performance program.
Reference


