MARKOV MODEL IN ESTIMATING THE TRANSITION PROBABILITIES OF RHINITIS IN CHILDREN, PURWOREJO LONGITUDINAL SURVEILLANCE STUDY

Senoarto Sastrowijoto
Department of Ear, Nose and Throat, Community Health and Nutrition Research Laboratory, Faculty of Medicine, Gadjah Mada University

Abstract

Key words: Model Markov, rhinitis - anak balita - survei rumah tangga longitudinal.

Introduction
The mathematical models have been used in analyzing the pattern of clinical features of various diseases, and to study factors which influence the prevalence of diseases. Markov process models are useful in studying the evaluation of certain system or process over repeated trials or observations. Markov processes are categorized according to whether the transition probabilities are constant over time or not. A special type of Markov process in which the transition probabilities are constant over time is called a Markov chain. The net probability of making a transition from one state to another during a single cycle is called a transition probability. The Markov process is completely defined by the probability distribution among the starting states and the probabilities for the individual allowed transitions.

This study is an attempt to apply Markov process modeling to health states of rhinitis in children. The main objective is
to examine the dependence of current health states, on previous history. Only two states of health are considered, a "Healthy" state denoted by H and an "Illness" state denoted by R (for rhinitis). Examinations of the switching pattern between these two states, from the first observations to the other with three-monthly intervals, and the dependence of the current state of health on preceding states will be noted.

The simplest model of dependence on the past is one that links the current state to the immediately preceding three-month observations, this is a Markov model. Since the process of the study has only two states (H and R) and are observed at a discrete time points (three-monthly intervals) the appropriate Markov model is therefore a discrete time model (Markov Chain) with two states.

Health institutions (district level and health center) have two main roles in reducing the burden of illness in the community, i.e. implementing preventive and promotive health activities and ensuring prompt recovery from illness when it occurs. This study is developed base on the idea that the result of the study can be used as a mean of measuring the impact to the above roles. The success of these roles can be measured directly by incidence rate of diseases within the community i.e. the probability of an illness occurring in a person who is initially well and the probability of well person who is initially sick recovering in the next period after treatment. Both of them are reflecting the probability in making transition from H --> R and R --> H.

Ideally the type of data required to determine the probabilities of this kind of issues should be obtained from a community study. Community Health and Nutrition Research Laboratories (CHN-RL) at Purworejo with its longitudinal surveillance component provides a good opportunity to obtain data for this study, i.e. to apply the Markov process modeling to health status switching behavior of rhinitis in under-five children.

Materials and Methods

The study population consists of all under-five children, collected from selected households in the longitudinal surveillance of Community Health and Nutrition Research Laboratories (CHN-RL) Gadjah Mada University conducted from October 1994 to September 1995 at the Purworejo District, Central Java. A two-stages cluster sampling method with Proportional Population Estimated Size (PPES) was used to select approximately 13,000 households representative for the district's total population.

Each household has a household record folder at the CHN-RL files. Record of children under-five were grouped upon the cycles of observations, cycle 1,2,3, and 4 (three-monthly intervals). The variables include age, date and diagnosis of rhinitis (states of health) at the first contact, together with diagnosis and data of subsequent visits. Data were collected by interviewer, who received special training for this longitudinal surveillance. It was assumed that the health states of the children throughout the three-month period was constant as reflected by the prevalence of recall during a two-week period. The transition of health states from one observation to the other could estimate the trend of being healthy or rhinitis during the study period.

The Markov Model

The Markov model assumes that, in any given three-month the state of health of the child depends on its previous history only through its health states in the preceding three-month. Only two states of health are considered in this study, health state denoted by H and illness state denoted by R (for rhinitis).
Transition probabilities

The starting point in the study of any Markov process is the probabilities of transition between two states from one point in time to another. In this study there are two states of health (H and R), and observations were conducted in three-monthly intervals. Therefore the transitions from one observation to the next could be: H \rightarrow H, H \rightarrow R, R \rightarrow H, and R \rightarrow R.

The corresponding probabilities denoted by \( P_{HH}, P_{HR}, P_{RH}, P_{RR} \). The \( P_{HH} \) represents the chance of child who was healthy in a given observation is again healthy in the following observation. While \( P_{RR} \) is the chance of child who was healthy in a given observation becomes ill (rinitis) in the following observation. The \( P_{HR} \) plus \( P_{RH} \) is one, similar interpretation apply to \( P_{HH} \) and \( P_{RR} \).

Estimation of transition probabilities

In estimating the transition probabilities of diseases, e.g. rinitis in this study, the observed proportions of children making the transition \( H \rightarrow H, H \rightarrow R, R \rightarrow H \) and \( R \rightarrow R \) will be modeled using Markov processes. The Markov process is completely defined by the probability distribution among the starting states and the probabilities for the individual allowed transitions. When these probabilities are consistent with respect to time, they can be represented by \( n \times n \) matrix transition probabilities.

Results

Data were collected from 12,721 households consisting of a total population of 50,955 which included 5,060 under five children, observed at Pruworejo district, through longitudinal surveillance, October 1994 - September 1995. The children at the first contact were divided into age groups of (0 - 5), (6 - 11), (12 - 23), (24 - 35), and (36 - 59) months.

Table 1 reveals some interesting features of the data under study. It is obvious from this table that the transition probabilities between cycles 1-2, 2-3, and 3-4 showed steady state that around 1/5 of healthy children became sick (rinitis) and 1/3 of the sick children suffered from rinitis in the following observation. The steady state may be reached by 5 month, and the proportion of probabilities are corrected to 1/5 and 1/3.

<table>
<thead>
<tr>
<th>Cycle of observations (season)</th>
<th>Children under - 5 transition probabilities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( H \rightarrow H )</td>
</tr>
<tr>
<td>1-2 (Rainy)</td>
<td>81.6</td>
</tr>
<tr>
<td>2-3 (Trans)</td>
<td>83.7</td>
</tr>
<tr>
<td>3-4 (Summer)</td>
<td>83.2</td>
</tr>
</tbody>
</table>
If the cycle of observations (interviews) were linked with the season, the 1 to 2 observations were conducted in rainy season, the 2 to 3 observations were conducted in the transition between two seasons, and the 3 to 4 observations were conducted during summer. In the rainy season the number of the healthy children becoming sick was higher (18.4) compared to the others (16.3 and 16.8). On the other hand, the percentage of sick children who are still suffered from rhinitis was lower (24.1) compared to the other observations (28.1 and 25.2). There was no clear dependence of transition probabilities between states to season, this might be due to short duration of observations.

The average transition probabilities during the study observations, cycles, 1, 2, 3, and 4 by age group is presented in Table 2. It is obvious from the table that at the age group of (0-5) months, the percentage of healthy children becoming rhinitis was lower (19.9) compared to the age group of (6-11) months (22.2). Starting from the age group of (6-11) to the older groups the proportions was declining gradually, from 22.2 to 21.8, 17.6, and 14.3.

Similar pattern could be observed from the children who suffered from rhinitis but still being sick. The proportion was declining by age.

Table 2.
The average transition probabilities, cycle 1 - 4 by age group

<table>
<thead>
<tr>
<th>Age groups (month)</th>
<th>H → H</th>
<th>H → R</th>
<th>R → H</th>
<th>R → R</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>60.10</td>
<td>19.90</td>
<td>73.13</td>
<td>25.87</td>
</tr>
<tr>
<td>6 - 11</td>
<td>77.83</td>
<td>22.17</td>
<td>71.26</td>
<td>29.74</td>
</tr>
<tr>
<td>12 - 25</td>
<td>78.20</td>
<td>21.80</td>
<td>71.33</td>
<td>28.67</td>
</tr>
<tr>
<td>24 - 35</td>
<td>82.43</td>
<td>17.57</td>
<td>73.13</td>
<td>26.87</td>
</tr>
<tr>
<td>36 - 59</td>
<td>86.70</td>
<td>14.30</td>
<td>80.83</td>
<td>19.17</td>
</tr>
</tbody>
</table>

* starting point of (6-11) months
↑ = increase
↓ = decrease

Table 3.
Transition probabilities of children for H → H and R → R on discrete time of observation

<table>
<thead>
<tr>
<th>Observations</th>
<th>N = 5,080</th>
</tr>
</thead>
<tbody>
<tr>
<td>H → H</td>
<td>170</td>
</tr>
<tr>
<td>R → R</td>
<td>170</td>
</tr>
<tr>
<td>H → H</td>
<td>4324</td>
</tr>
<tr>
<td>R → R</td>
<td>3219</td>
</tr>
<tr>
<td>H → R</td>
<td>2494</td>
</tr>
<tr>
<td>R → H</td>
<td>1574</td>
</tr>
</tbody>
</table>
Table 2 described the proportion of transition probabilities of rhinitis in children, and Figure 1 showed its features by age groups. Both the table and the figure were developed from the same data. Starting from the observation on (6-11) months of age, there were declining proportion of transition by age groups. The transition probabilities (P_{in} and P_{in}) showed some dependence on age of the children. This means that the state of health in the following observation depends not only on the current state, but also on the age of children. From the (6-11) month onwards the data showed clearly that the proportions decreasing from then on.

The transition probabilities of P_{in} and P_{in} increased from the age of (0-5) to the (6-11) group. The transition probabilities of P_{in} and P_{in} have a similar pattern but the proportion of transition probabilities increasing by age groups, since the (P_{in} + P_{in}) or (P_{in} + P_{in}) = 3.

Table 3 showed the proportion of transition probabilities of children who are well and still healthy (H -- > H) during all cycle of observations, and other group of children who suffered from rhinitis and still sick (R -- > R) in the following observations were declining. It seems that the transition depends not only on age groups but also on the other factors.

Discussion

The transition between health and rhinitis of under five children can be modeled by a Markov chain, and results in dependency on age and time. After five months the transition probabilities of children who are well and become sick (H -- > R) and the proportion of children who become sick were increased. In the following cycles, starting from the age group of (6-11) month, the proportion then on decreased (Table 2 or Fig. 1). The explanation for this may be that by age (time) the children were influenced by the environment. The initial health state of the children depends on the role of maternal antibodies that give protection against common children diseases including runny nose (rhinitis). These antibodies will be minimal by the fifth months after birth, similar with the result of Binkwum and Odoo study. Those children who have adequate maternal antibodies get protection from diseases, while those without are not protected. The other possibility is that this state of health is due to the impact of preventive and promotive health activities by the health center over a period of time. As the children grow up, it appears that congenital factor will become less dominant, while environmental health factors take over.

The P_{in} and P_{in}, namely new rhinitis arising from the population of well children (H -- > R) and continuing illness following previous rhinitis (R -- > R), can be considered as a mean for measuring the success of health care delivery programs. It does mean that the estimate of transition probability may be used to assess the expected impact of health improvement program. This kind of information provides a useful indication of the prevalence of illness in the community, particularly if the period of data collection was long enough, not only one year but may be three to five years.

In one of community-based study in London (1991) upon 15-65 years old populations showed the prevalence of allergic rhinitis was 16%, of these 8% had perennial symptoms, 6% both of perennial and seasonal, and 2% seasonal allergic rhinitis. Similar to the above study, ten-year evaluation of intradermal skin test for allergic rhinitis diagnosis, showed that perennial symptoms (house dust 76.2% and human dander 72.6%) was more prevalent compared to seasonal symptoms (moulds 38.8% and pollen 3.3%). These two studies indirectly support that the transition of rhinitis may depend on season. The etiology of rhinitis are due to
allergic background (seasonal and perennial), infection, and unknown; this third group which is poorly understood, described as vasomotor rhinitis. The mechanisms involved in usually multi-factorial, included dietary, hormonal, environmental and emotional factors. Acute infective rhinitis is usually viral infection and quickly self-limited, secondary bacterial infection may occur and at time may lead to severe sinusitis. The pathophysiology of allergic rhinitis is starting by allergen stimulate mast cells, T-lymphocytes, Langherans's cells, and eosinophils. Histamine, released from mast cells is responsible for itching and sneezing by stimulation of H1 - receptors in the nerves causing glandular secretion, and watery rhinorhoea. It is likely that leukotrienes, prostaglandin, kinins, and the other mediator substances contribute to mucous hypersecretions and especially to the vascular reaction (edema and vaso-dilation). Based on the above conditions rhinitis is usually multifactorial, community-based study on the etiology of rhinitis is suggested.

Due to the fact that CHN-RU was planned for five years or may be more, this Markov model in estimating the transition probabilities of rhinitis in children can be extended for the other years of observations. It is possible to extend this model involving more than two health states, for any priority health problems, e.g., dengue hemorrhagic fever, malaria, tuberculosis, etc.

References