COST BENEFIT ANALYSIS OF JAPANESE ENCEPHALITIS VACCINATION PROGRAM IN THAILAND

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Abstract. Using decision analysis, we estimated benefits, risks, and costs of implementing the Japanese encephalitis (JE) vaccination program in children aged 18 months and 6 years in Thailand. The costs for inclusion of JE vaccine into the routine immunization program at 18 months and 6 years are $2.16 and $3.68 per person, respectively. In the baseline model, the JE vaccination program will prevent 124 JE cases in the program for 18 months old children and 153 JE cases in the program for 6 years old children. The 18 month child program is more cost-effective than the 6 year child program. The cost-effectiveness ratio in the 18 month child program is $15,715 compared with $21,661 in the 6 year child program. The benefits of the JE vaccination program are the savings in treatment cost, disability care, and the future lifetime earnings from JE prevented. The 18 month child program will save $72,922 per one prevented JE compared with $66,197 in the 6 year child program. The JE vaccination program is cost-beneficial under the base-case assumption. Sensitivity analysis which alters various assumptions indicates that the JE vaccination program is worth implementing unless the incidence of JE is less than 3 per 100,000 population. Otherwise, the cost of vaccine has to be reduced.

INTRODUCTION

Japanese encephalitis (JE) is a mosquito-borne arboviral disease with high mortality and serious sequelae. Survivors commonly suffer from motor paralysis and mental retardation. There were 1,500-2,500 reported viral encephalitis cases annually during 1976-1987 in Thailand (Sangkawibha *et al*, 1992). Seventy percent of clinical encephalitis occurs in children less than 15 years old. The attack rate is highest in 5-9 year-old children, followed by 0-4 year-old and 10-14 year-old children, respectively. The higher mortality and more serious sequelae are observed in younger children (Schneider *et al*, 1974). Control measures include vector control, protection of animal reservoirs, prevention of mosquito-bites, and vaccination (Thongcharoen, 1989). Inactivated vaccines have been manufactured and shown to be efficacious in China and Japan (Tsai,1994). A double blind field study of two doses of JE vaccine revealed 91% efficacy in Thailand (Hoke *et al*, 1988). For developing countries, the high cost of vaccine is the main barrier to inclusion of the JE vaccine into the routine immunization schedule. The Thai Ministry of Health is responsible for meeting the costs of immunization and treatment of the majority of JE cases. An effective JE vaccination program would be an attractive intervention if reasonable cost-benefit can be demonstrated. An economic analysis can provide information for a public health system with limited resources (Creese, 1982). In this paper, the authors present, from the provider perspective, the results of a study designed to identify alternative JE vaccination program, and the benefit-cost ratio of using JE vaccine to prevent JE.

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MATERIALS AND METHODS

The analytical model

The existing clinical and epidemiological data were used to determine the decision tree and vari-

ables contributing to an assessment of risks of JE infection, costs of the JE vaccination program, and benefits from prevention of JE illness. Two strategies were identified for implementing the JE vaccination program in Thailand. The first strategy is to vaccinate 18 month-old children concurrently with the 4th dose of DTP. The second JE dose would be given 1-2 weeks later. The second alternative is to vaccinate 6 year-old children in school concurrently with the routine school immunization program. The decision tree for the JE implementation program compared with no vaccination is shown in Fig 1. A cohort of one million children has been assumed for each strategy. The probability of each branch at the chance node is based on available published data. When published data are not available the risks and benefits of the vaccine have been purposely underestimated. The proportion of children experiencing each outcome at the tip of the decision tree is equal to the product of the probabilities along the branches leading to that outcome. Thus, the decision tree allows an estimate of the number of persons in a cohort who experience each outcome and permits a comparison of alternative vaccination strategies. Sensitivity analysis for uncertain estimates has been made to assess their effects on the outcomes.

Estimation of JE infection and outcomes of disease

In Thailand, viral encephalitis is a notifiable disease and is reported based on the clinical diagnosis. The overall reported viral encephalitis rate is between 2 and 5 cases per 100,000 population annually. The reported incidence in children less than 15 years is about 10 cases per 100,000 population. JE contributed at least 50% of all viral encephalitis (Sangkawibha *et al*, 1992). However, it is believed that the true incidence rate of JE is considerably higher than indicated by the surveillance system. The seroprevalence of JE infection increases with age. The natural immunity used in this calculation is 5% at 18 months and 30% at 6 years. It is estimated an average of 4.7% of children are infected with JE annually (Rojanasuphot *et al*, 1992). Assuming the ratio of apparent to inapparent cases is 1:300, the incidence of clinical JE illness is estimated to be 15.8 cases per 100,000 annually. The incidence in 6-10 year old children is 1.2 fold more than in those who are in the 0-4 year old group. We will use incidences of 15 and 18 cases per 100,000 for the baseline calculation at 18 months and 6 years, respectively.

The clinical symptoms of JE usually include an abrupt onset of fever, change in mental status and headache, followed by disturbance in memory, speech or motor dysfunction. Seizures occur in more than 75% of pediatric cases (Tsai , 1994). About 20-40% of cases are fatal. If they survive, some children have residual neurological deficits. In this analysis, we estimated one year outcomes of JE illness in four categories: 25% of JE cases died, 15% had severe disability, 25% had mild disability, 35% had full recovery.

Estimation of costs of vaccine

The operational cost has been determined for the JE immunization program. The meaning of cost in this study is the direct cost which includes vaccine with 10% wastage, labor cost, and supplies which include syringes and needles. The building and cold chain costs were not considered because this program is added to the routine immunization program both in the expanded program on immunization (EPI) and the school program. Complications due to the vaccine are minor and usually expected to be confined to local reactions (Hoke *et al*, 1988). We did not include the cost of treatment for complications in the analysis.

Benefit from JE vaccination program

Three components are included in the estimation of benefit from the JE vaccination program: 1) savings in treatment cost of acute JE illuess; 2) savings from prevention of death and; 3) savings from prevention of mental retardation.

Cost of JE treatment is estimated from the average cost of treating *Haemophilus influenzae* type B meningitis with adjustment for 1995 value (Levine *et al*, 1995). The human capital approach is used to calculate the cost of mortality. The future life time earning is calculated from expected gross national product per capita during ages 18-60 years and discounted for present value. Prevention of severe mental retardation includes savings for nursing care of the disabled and saving of future foregone earnings. The cost of severe neurological deficit care is derived from the expense of disability care for a lifetime of 20 years (Kajornpadungkitti *et al*, 1988). Children who have moderate disability are assumed to have 80% quality of life. Prevention of moderate disability will save 20% of future earnings for 42 years. All future costs are discounted to

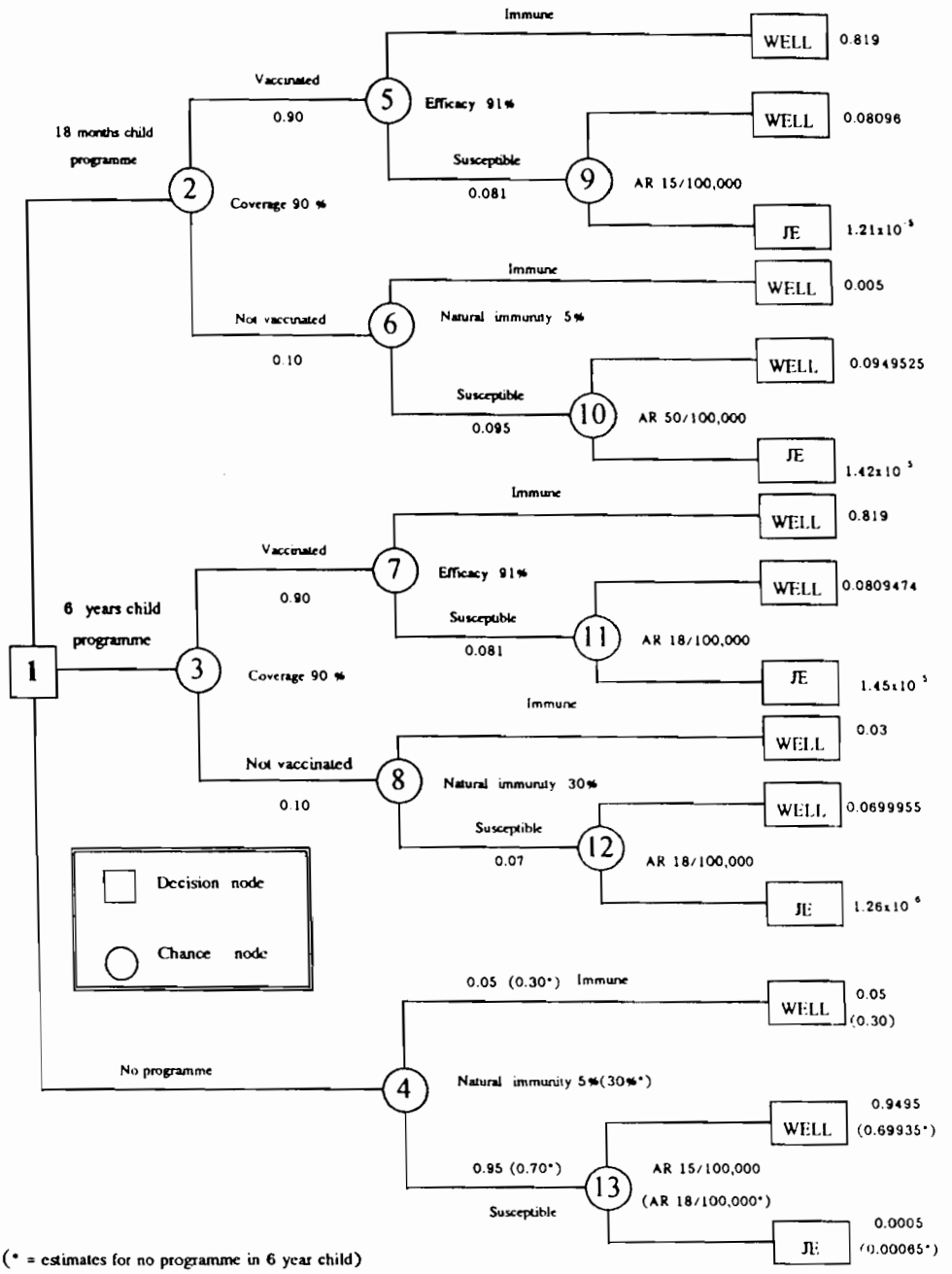

Fig 1 – Decision tree on strategies for JE vaccination.

present value at an annual rate of 5%. We use these estimates and outcomes of JE illness for calculating the benefits of one prevented case of JE.

RESULTS

The unit cost of two doses of JE immunization is $2.16 and $3.92 in the 18 month child and 6 year child programs, respectively. This cost includes vaccine cost, a $0.16 supply cost and a $0.24 labor cost. The cost of vaccine in the 6 year child program is $3.52, as twice the amount of vaccine is used compared to $1.76 in the 18 month child program. The overall costs of the immunization program for one million children aged 18 months and 6 years with 90% coverage are $1,944,000, and $3,528,000, respectively.

In the baseline model, clinical 124 JE cases will be prevented in the 18 month child program in one year. Death will be prevented in 31 children, severe disability prevented in 19 children, and moderate disability prevented in 31 children. The cost effectiveness ratio is $15,715 per one JE case prevented. In the 6 year child program, 152.9 JE cases will be prevented in one year. The cost effectiveness ratio is $21,661 per one JE case prevented.

The cost of acute treatment for JE is estimated to be $1,660 per case. The future life time earnings in an 18 month child and a 6 year child are $152,598 and $137,655, respectively. The estimates of savings of one JE disability is $169,878 and $154,935 respectively in the two progams. Prevention of one moderate disability case saves $30,520 and $27,531 in these programs, respectively. The total benefit of one prevented JE illness includes the cost of acute treatment and the product of the probability of the JE outcomes multiplied by the estimates of expenditure in each case. The overall benefit of each program is $9,2020,451 and $10,121,521, respectively. Both programs are cost beneficial. The benefit of the immunization program is eliminated when the benefit: cost ratio is less than 1. The benefit-cost ratio for the 18 month child is 4.6 and is 2.87 in the 6 year child program (Table 1).

Sensitivity analysis

The incidence of JE and cost of vaccine which are the main factors affecting the decision for including JE vaccine in the overall program are altered in this analysis. Table 2 presents the benefit/cost ratio for the JE program in 18 month old children. The JE program is still cost beneficial unless the JE incidence is less than 3 per 100,000 population, at which point the cost of vaccine would have to be reduced. The benefit/cost ratio of the 6 year child program under various incidence and vaccine costs is shown in Table 3.

DISCUSSION

JE is a major public health problem in Thailand. The private sector began JE vaccination for children in 1986. However, the cost of the vaccine has been the main barrier to accessing this prevention program for most of the population. The Thai government implemented JE vaccination in selected target groups in the northern part of the country in 1990. The reported incidence of viral encephalitis decreased from 4/100,000 in 1985 to less than 1/100,000 in 1994. This decision analysis can assist the government in selecting target populations, and comparing the benefits of a vaccination program to other new health program.

The JE vaccine is included in the routine immunization for the strategic selection because this alternative can save half of the labor costs and also does not need additional investment in buildings and the cold chain. JE vaccination is not included in the first year of life because two of the three doses of DTP vaccine (at 2, 6 months) are concurrently injected with hepatitis B vaccine in that period. Therefore 18 months was selected as the target age for JE vaccine. Six years was selected for program analysis because of the high incidence in this age group and the practical considerations of vaccine administration in the schools. JE vaccination simultaneously with DTP or dT vaccine in either program is safe, effective, and practical (Mathurosapas *et al*, 1989; Rojanasuphot *et al*, 1992a).

In the cost benefit analysis, we considered the costs of intervention and outcome in monetary terms. There is no agreement concering the best way to value human life. The human capital approach is used because this method is simple and provides reliable, consistent, and conservative estimates. Willingness to pay is an alternative method for valuing human life. However, this method

Table 1

Estimation of costs and benefits of JE immunization program.

Category	18 month child program	6 year child program
Cost		
Unit cost of immunization	$2.16	$3.92
Overall cost of program	$1,944,000	$3,528,000
Effectiveness (case prevented)	123.7	152.9
Cost/effectiveness ratio	$15,715/case	$21,661/case
Benefit from one prevented case		
saving in treatment cost	$1,660	$1,660
saving from reduced mortality	$38,150	$34,414
saving from reduced severe disability	$25,482	$23,240
saving form reduced moderate disability	$7,630	$6,883
Total savings from one JE illness	$72,922	$66,197
Overall benefit of program	$9,020,451	$10,121,521
Net benefit of program	$7,076,451	$6,593,521
Benefit/cost ratio	4.6	2.87

Table 2

Sensitivity analysis of the benefit-cost ratio for JE vaccination program at 18 months by varying the JE incidence rate and the vacine cost.

JE incidence	Vaccine cost		
	$1.76	$1.32	$0.88
15/100,000	4.64	5.83	8.79
10/100,000	3.09	3.88	5.22
5/100,000	1.55	1.95	2.61
3/100,000	0.93	1.17	1.57
2/100,000	0.62	0.77	1.04

Table 3

Sensitivity analysis of the benefit-cost ratio for JE vaccination program at 6 years by varying the JE incidence rate and the vacine cost.

JE incidence	Vaccine cost		
	$3.52	$2.64	$1.76
18/100,000	2.87	3.70	5.21
10/100,000	1.59	2.05	2.89
5/100,000	0.80	1.03	1.45
4/100,000	0.63	0.82	1.16

provides higher estimates than the human capital approach.

At the present cost of the vaccine, JE vaccine is a cost beneficial intervention. Children less than 3 years should be the first priority due to the greater cost effectiveness. The smaller amount of vaccine used and the larger benefit make this alternative attractive. The JE vaccination is also a worthy prevention program for school children in high risk areas where the incidence of JE is more than 5/ 100,000 population.

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