

ECONOMIC BURDEN OF VARICELLA IN SINGAPORE - A COST BENEFIT ESTIMATE OF IMPLEMENTATION OF A ROUTINE VARICELLA VACCINATION

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Abstract. Varicella is a common childhood illness that can result in significant morbidity and mortality. As early as 1995, recommendations for routine varicella vaccination have been published, but have not been universally implemented, with cost of vaccination as a major reason. Though available from 1996, the vaccine has yet to be routinely implemented in Singapore. We set out to assess the economic burden of varicella and the cost-benefit of adding a varicella vaccine to the existing immunization schedule in Singapore. In this study, using data from 1994-1995 the direct cost estimates were based on all levels of medical care; inpatient care, emergency room visits, primary health care and medication. Indirect costs were estimated from the cost of time lost by patients and their families attending to medical needs, as well as loss of productivity due to absenteeism. The cost of a vaccination program targeted at 15-month old infants receiving concomitant measles-mumps-rubella immunization was also assessed. The cost-benefit ratio was then estimated. The total cost of varicella in Singapore was estimated to be US\$11.8 million per annum. The loss of productivity accounted for a large proportion of the total cost as a lot of parents took leave when their children were ill. The estimates of total cost represent approximately US\$188 per varicella case per year. In comparison, the cost of a vaccination program was found to be US\$3.3 million per annum. The cost per case averted was US\$104. From a societal point of view, for every dollar invested in a vaccination program, we would save about US\$2 dollars.

INTRODUCTION

Although varicella is often perceived as benign childhood illness, serious complications may occur especially in the immunocompromised, healthy adults, pregnant women and neonates. In Singapore, varicella is a notifiable disease by law. There were about 40 and 23 thousand cases in 1994 and in 1995, respectively (Quarantine and Epidemiology Department, 1997). There were 17 deaths due to complications of varicella in healthy adults from 1994-1996, the leading cause being encephalitis (Lam *et al*, 1993).

In contrast to populations in temperate climates where varicella is a childhood disease, infection with varicella in the tropics occurs later, increasing the risk of severe morbidity and mortality (Quarantine and Epidemiology Department, 1997; Lee, 1998). The morbidity and mortality of varicella is currently preventable with the widespread

availability of the live attenuated Oka strain varicella vaccine (Weller, 1996). In fact, varicella is currently the leading cause of death that is preventable by vaccination in the United States (Gershon, 1994), and this is a factor in the American Academy of Pediatrics recommendation of routine concomitant immunization of infants with measles-mumps-rubella and varicella (Holmes, 1996). This vaccine is not included in the childhood vaccination schedule of most other countries, including Singapore. It has been available in Singapore since 1996. Apart from the medical consequences of the disease, a significant aspect of the burden of the disease is also its economic cost. It was with these factors in mind that this study was carried out.

MATERIALS AND METHODS

Cost of varicella to the community

Direct costs. The data on the use of health care resources were collated by the Research and Epidemiology Department, Ministry of Health, Singapore (Quarantine and Epidemiology Department, 1997). The cost estimate was made

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for 1994 and 1995, as the data for that period was the most comprehensive. The estimates were calculated and converted to the 1994/1995 US dollar based on the average rate for those years and based on the current methods of estimating cost of illness (Preblud, 1988; Ross, 1988; Lieu *et al*, 1994; Beutels *et al*, 1996). Data on hospitalization, emergency room, and primary healthcare visits for varicella were obtained for all public and private health care centers in Singapore for 1994-1995. The usage of acyclovir was obtained from its suppliers [data provided by Intercontinental Medical Statistics (Asia) Pte Ltd]. As acyclovir is also used to treat herpes simplex, the cost of acyclovir used to treat herpes simplex and zoster was excluded by extrapolating its use to proportion of such cases treated at government and family practitioner clinics (Emmanuel *et al*, 1994). The cost of varicella-zoster immunoglobulin (VZIG) was factored in by extrapolating data from the National University Hospital to the other 5 large hospitals in Singapore, which see a comparable number of cases.

Indirect costs. The cost of time spent attending to medical visits was adopted and modified from the methodology described by Ross (1998). The loss of productivity due to absence from employment was ascertained from data of hospitalization from the Research and Epidemiology Department, Ministry of Health, Singapore. Using local labor force participation rates, the patients from age 15-19 years were not included in the calculation as it is assumed that they do not require caregiver leave and form a small minority of the working population (Huse *et al*, 1994). For patients aged 0-14 years, 1.6 days lost from work for caregivers were used (Lieu *et al*, 1994), and for adults (>20 years) we assumed 7 days medical leave for varicella, which is the average duration of medical leave granted (unpublished data from Department of Community Medicine, National University of Singapore). We took into account the average labor force participation rate of 64% in Singapore between 1994 and 1995. The average cost per employed person per day was estimated from the Ministry of Labor's estimates and was US\$49.2 a day, averaged for that period.

Cost of a vaccination program

Direct costs. In this study, we looked at implementing a program of varicella vaccination for the population of 15-month old infants in 1993 together with the MMR vaccine. This timing was recommended by earlier studies (Hong and Goh, 1992; Gershon, 1995; Holmes, 1996) so as to minimize the administrative cost of vaccination by incorporating both vaccines in one visit. The price of the vaccine in Singapore in 1993 was US\$43. The model assumed that there would not be any waning immunity (Preblud, 1988; Asano, 1996). It was also assumed that the entire cohort of 15-month infants never had varicella.

Indirect costs. We assumed that 2% of the vaccinated subjects would develop vaccine complications such as pain at the injection site or rash, and would result in one day of work loss (Lieu *et al*, 1994). The protection from varicella was taken to be 90% following vaccination.

Cost to benefit ratio

The estimation of cost to benefit ratio was made based on the methodology described by Preblud (1988). The cost of disease that cannot be prevented is an overestimation, as this would include breakthrough infections. In a previous study, the cost of breakthrough infection was found to have little impact on the cost benefit of a vaccination program (Brisson and Edmunds, 2002).

Cost of a catch-up program

The cost for a catch-up vaccination program administered over a period of one year was also estimated. The Singapore population does not reach a seroprevalence of over 90% till the age of 34 years (Ooi *et al*, 1992). The target population for the catch-up program would have to include children of 2 years to adults aged 34 years as these age groups form the majority of non-immune varicella subjects in Singapore. We did not include the cost of serology testing in those with an uncertain history of varicella as data has shown that this is only cost effective for adults above 30 years of age (Smith and Roberts, 2000).

RESULTS

Cost of varicella to the community

The total cost of varicella in Singapore for the year 1994-1995 was estimated to be about US\$11.8

million per annum (Table 1). These costs represent approximately US\$188 per patient (Table 2).

Cost of a vaccination program

The total cost of a vaccination program was estimated about at US\$3.3 million (Table 2). This includes the actual cost of the vaccine and takes into account the cost of disease that cannot be prevented plus loss of productivity due to complications.

Cost to benefit ratio

The overall savings of having a vaccination program is about US\$2.6 million (*ie* US\$ 11,796,203/2 – US\$3,299,839). The cost to benefit ratio is 2.25:1. This means that for every dollar invested in vaccination, there would be a savings of US\$2.25 dollars (Table 2). The cost per case averted is US\$104.

Cost of a catch-up program

The cost of a catch-up program was estimated to be approximately US\$42 million dollars (Table 2). Based on the savings of approximately US\$2.6 million per annum obtained from immunizing a

single cohort at 15 months, the cost of the initial catch-up vaccination program would be recovered only after 16 years or more.

The recovery of cost of this catch-up program could, however, be shortened with the lowering of the vaccine price. For example, if the vaccine price could be lowered by 40%, this would enable recovery of the cost incurred from the catch up program within 10 years (Table 2).

DISCUSSION

This study provides information on the economic cost of varicella in a tropical country. The bulk of the cost of varicella in Singapore was contributed by the indirect cost of the disease. This arose largely from loss of workdays of affected adults. This contrasts significantly with that of the United States, where varicella is mainly a disease of childhood, and loss of workdays arose from those of caregivers of infected children (Lieu *et al*, 1994).

When the overall cost of varicella was compared between Singapore and USA, it was noted

Table 1
Costs (US\$) of varicella in Singapore, 1994-1995^a.

Expenditure		Cost in US\$
Medication	Acyclovir	175,733
	Injection Tablets	1,173,740
Hospitalization	Varicella Zoster immunoglobulin	24,401
	791 admissions with 4,372 bed days	812,542
Outpatient visits	Emergency room	34,779
	General practitioners	361,793
	Government polyclinic	58,117
Loss of productivity	Patients aged 0 to 14 years	2,291,618
	Patients aged 20 to 64 years	6,863,481
Total costs		11,796,204

^aFor method of calculation, please see text.

Table 2
Cost benefit of a varicella vaccination program.

	Total cost	Unit cost per patient
Expenditure (1994-1995)	\$11,796,204	\$188
Vaccination program	\$3,299,839	\$83
Vaccination catch-up program:		
1. US\$42.5 per dose	\$42,420,398	\$1,072
2. US\$25.6 per dose (with 40% lowering in future)	\$25,492,070	\$644
Cost per case averted		\$104
Cost:Benefit ratio		2.25

that the cost per case of varicella was higher in Singapore (USA=US\$130, Singapore=US\$188). This was rather surprising, as healthcare costs in the USA are generally higher than in our community. For example, a previous study showed that treating asthma in the USA (US\$640/patient) was much higher than in Singapore (US\$257) (Chew *et al*, 1999). A probable factor contributing to the higher cost of treating varicella in Singapore is the difference in age specific incidence; the proportion of adults affected being higher in Singapore, thus causing a higher cost in terms of loss of workdays. Our results indicate that universal vaccination was indeed cost beneficial, with a cost benefit ratio of 2.25:1, however, the cost savings was mainly from a societal perspective rather than the health care payer's.

Studies done in several western populations including the United States, Germany, France, Spain, and Australia (Huse *et al*, 1994; Lieu *et al*, 1994; Beutels *et al*, 1996; Coudeville *et al*, 1999; Diez Domingo *et al*, 1999; Scuffham *et al*, 2000; Streeton *et al*, 2001) have also found cost-benefits in favor of a routine childhood vaccination program incorporating simultaneous measles-mumps-rubella and varicella vaccination. However, policy makers also would have to base their decision on the practicalities of the actual burden is from the health care payer's perspective.

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