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Cost-Benefit Analysis of a *Haemophilus Influenzae* Type B Meningitis Prevention Programme in The Philippines

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Abstract

Background: *Haemophilus influenzae* type b (Hib) meningitis is associated with high mortality and serious sequelae in children under 5 years of age. Vaccines which can prevent this infection are available.

Objective: To evaluate the costs and benefits of a 3-dose immunisation schedule in Manila, Philippines.

Perspective: Government and societal perspectives.

Design and participants: A cost-benefit analysis based on a birth cohort of 100 000 children. The state of health of the cohort with and without a Hib immunisation programme was modelled over a 5-year period. A survey of medical records of patients with Hib in Manila provided data on the extent and cost of sequelae following infection.

Intervention: A 3-dose Hib vaccination programme given at ages 2, 3 and 4 months.

Results: The model predicted that vaccinating children against Hib meningitis would prevent 553 cases per year in a birth cohort of 100 000, at a cost of 56 200 Philippine pesos (PHP) [$US1605; 1998 exchange rate] per case (base case assumptions of 90% vaccine efficacy rate, 95 per 100 000 Hib incidence rate, 85% vaccination coverage). Results from the cost-benefit analyses indicated that the saving to the government would be around PHP39 million ($US1.11 million), and the saving to society would be PHP255 million ($US7.28 million).

Conclusion: There would be a positive economic benefit for the Philippine government and for the Filipino society if a Hib vaccination programme was introduced in Manila.

Haemophilus influenzae type b (Hib) meningitis is a significant problem in Manila, Philippines as demonstrated by the high incidence rate of 95 per 100 000 in children less than 5 years old.[1] This incidence rate is higher than the incidence rates in other non-western populations (which range from 25 in Chile[2] to 60 in The Republic of Gambia[3,4] per 100 000 of children <5 years of age) and in

western populations (20 to 50 per 100 000 of children <5 years of age).[5-7] However, it is much lower than the incidence rates reported for indigenous populations (which range from 475 per 100 000 for indigenous Alaskans[4] to 530 per 100 000 children <5 years for Canadian Inuit[8]). In the Philippines, as in other countries, not only does Hib meningitis have a relatively high mortality rate (11%), it is also associated with a high rate of sequelae (15%). The reported sequelae include hearing loss, ataxia, mental retardation, speech delay, obstructive hydrocephalus and visual impairment.[9,10] Fortunately, Hib meningitis can be prevented using effective vaccines.[11]

Since Hib conjugate vaccines have become available, a number of economic studies have been performed in various countries; results from these analyses support vaccination.[12-21] However, no such evaluation has been conducted in the context of the Philippine health environment. In this study, we performed a cost-benefit analysis of the possible implementation of a Hib vaccination programme in Manila. All future costs associated with long term health effects from Hib meningitis were considered. The perspective taken is that of the government and of society.

Methods

Epidemiological Data and the Model

Data from an epidemiological study conducted in Manila[1] were used. Hearing loss, originally categorised as a severe sequela in the study, was reclassified as a less severe outcome to conform to the classification used by other studies.[14,16] The number of cases that would occur with and without the immunisation programme in a birth cohort of 100 000 children until they reached 5 years of age was estimated using a similar model to that used by Harris et al.[14] to estimate Hib meningitis incidence and outcomes. A 5-year cohort was chosen because meningitis infection most often occurs in this age range.

Using a spreadsheet program, Microsoft Excel version 5.0,[22] the state of health of the cohort with and without a Hib immunisation programme was modelled each month for a 5-year period. A simplified diagram of the model is presented as a decision tree in figure 1; the model was assessed for face and content validity by a clinical epidemiologist and by 2 infectious disease experts. Each month starting from birth, children in the cohort have a given risk of developing Hib meningitis. If, by chance, the child develops Hib meningitis, he or she has a given risk (or probability) of developing either severe or mild sequelae, of dying or of full recovery. Children who develop Hib meningitis leave the cohort, and those who do not develop Hib meningitis pass through the next period and become the population at risk of Hib meningitis on the succeeding month. This cycle continues until the children in the cohort reach the sixtieth month.

Two strategies against Hib meningitis were analysed. These were: (i) a no vaccination programme; and (ii) a government-funded vaccination programme coinciding with the usual DTP schedule at 2, 3 and 4 months. Table I lists the assumptions used in estimating the outcomes of the Hib vaccination programme in Manila.

Costs

Discounting

Costs were expressed in Philippine pesos [PHP; $US1 = PHP35 (1998 exchange rate)]. All future costs were converted to 1998 dollar values using discounting[28] at a rate of 5% per year.

Cost of Hib Meningitis

The items included in the cost-benefit analysis and their associated costs are listed in table II. It was assumed that all cases had a 15-minute visit to a GP before referral to hospital. The cost of the length of hospital stay was derived using the cost per day of stay in a ward and in an intensive care unit. Hospital costs were based on the average costs of treatment in a standard ward and in an intensive care unit per day for medical care, tests and drugs. All costs were determined from the Philippine General Hospital costs.

It was assumed that all children who experienced some form of moderate disability as a result of Hib meningitis would require special education

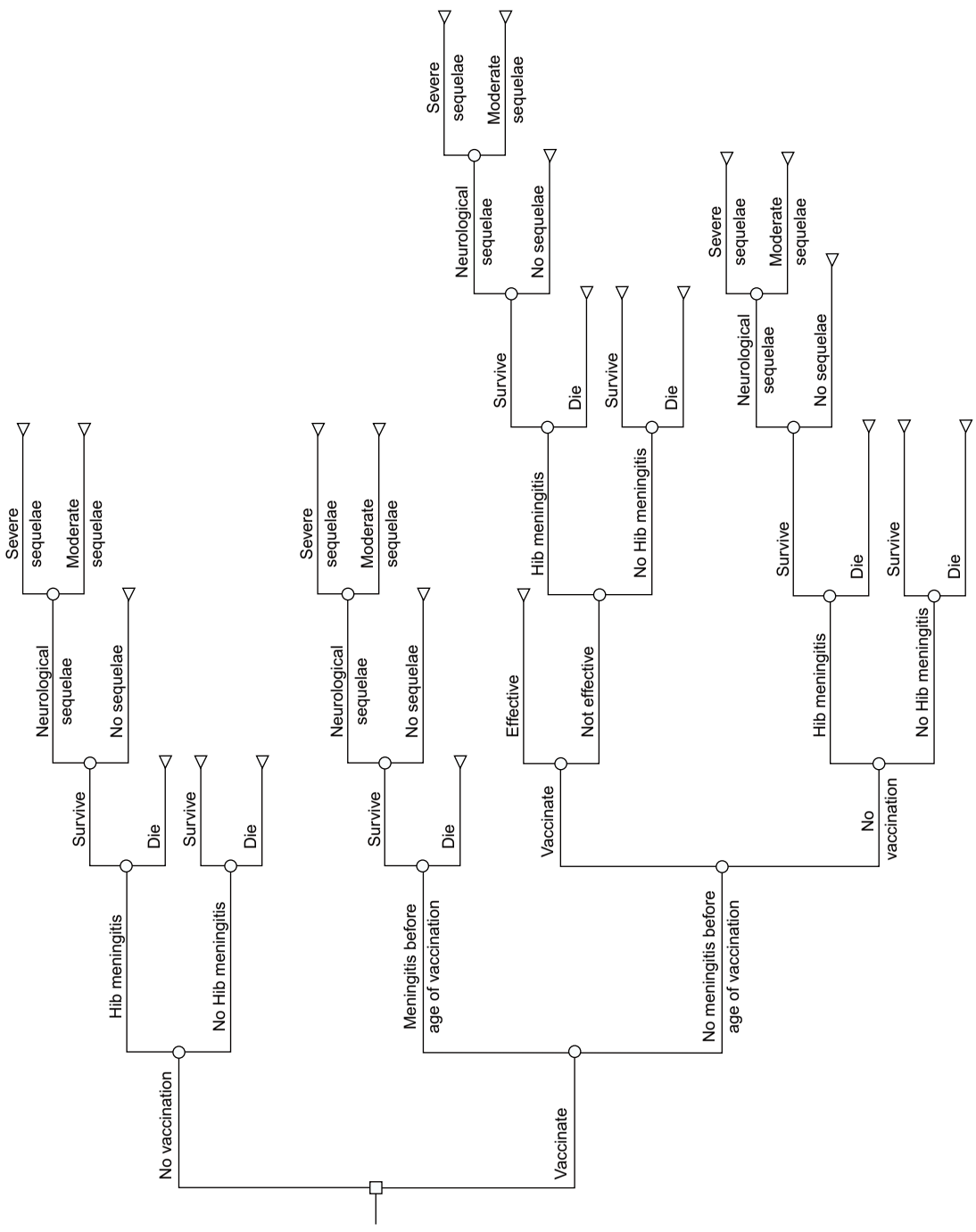

Fig. 1. Decision tree diagram of *Haemophilus influenzae* type b (Hib) meningitis prevention strategies. **Circle** = chance node; **square** = decision node; **triangle** = outcome.

Table I. Summary of variables used to estimate the outcomes of *Haemophilus influenzae* type b (Hib) vaccination in Manila

Variable	Value
Hib meningitis incidence per 100 000 children <5 years old	95[1]
Probability of all causes of childhood mortality per 100 000 birth cohort[23]	
<1 year of age	0.0582
1-5 years of age	0.0168
Case fatality rate[1]	0.110
Probability of no sequelae[1]	0.828
Probability of sequelae[1]	0.172
severe[a]	0.388
moderate[b]	0.612
Annual birth cohort	100 000
Life expectancy (years)[23]	65
full recovery	65
with moderate sequelae[b]	50
with severe sequelae[a]	40
Vaccine effectiveness[20,24,25]	90%
Vaccination coverage[26]	85%
Vaccination schedule[27]	2nd, 3rd and 4th month

a Severe physical (e.g. hemiparesis, quadreparesis) and mental disabilities and severe mental retardation.

b Diagnosed sensoneural hearing loss, mild speech difficulties, diagnosed seizure or epileptic condition controlled by anticonvulsant medication, gait abnormality and coordination problems.

(i.e. having to enrol in a special school for the hearing impaired). The marginal cost of special education in Manila was conservatively estimated to be PHP4000 per year per child.

For children with severe disability or sequelae, long term care would be required. However, the cost of long term disability is difficult to measure with precision; estimates for the costs of different degrees of disability in the Philippines were not available. The cost of severe disability requiring residential care (including costs of home devices and aids) was conservatively estimated to be PHP12 000 per year.

For children with hearing impairment, the cost of a hearing-aid was at least PHP10 000; replacement is required every 5 years. Cochlear implant, a procedure which can have a substantial impact on children with a hearing deficit, is not available in the Philippines and was therefore not considered as an option.

Additional costs incurred by one of the parents taking time off work to care for their child in hospital (including 5 days after discharge) as well as travel costs were taken into account. Costs incurred by a parent whose child had severe disability were calculated as follows: it was assumed that full-time care would have to be provided by a parent at a yearly cost of PHP52 000, equivalent to the current yearly minimum salary (with a 10% increase every 5 years).

Although difficult to estimate, the value of a life lost was estimated using the human capital approach;[29] the loss of income from the age of 20 years up to the age of 65 years (had the child survived in full health) was estimated. Annual earnings of PHP52 000 (based on the minimum wage), with a 10% increase every 5 years, was used in calculating future earnings of an individual. Because not everyone will be employed, the national unemployment rate of 9%[27] was factored in the calculation.

Cost of the Vaccination Programme

Studies have shown that diphtheria-tetanus-pertussis (DTP) and Hib vaccines can be safely combined.[24,25] It was, therefore, assumed that the Hib vaccination programme would be incorporated into the existing vaccination programme of the government; thus, the marginal cost of administration would be minimal. Table II lists the components of the programme costs that were considered in order to provide 3 paediatric doses of conjugate vaccines to the birth cohort. The total cost of vaccinating a child was PHP470.80 (table III). The cost of the vaccine was PHP150 per dose, equivalent to the price per dose other governments were able to negotiate.[16]

With the inclusion of a Hib conjugate vaccine in the Expanded Program on Immunization,[30] the following assumptions were made:

1. Five minutes extra public health nurses' time per vaccination; no extra parental time off work; no extra transportation costs for either children or parents.

2. The costs of storage and wastage were not included in the calculation of the programme cost. However, assuming that wastage is the same as for oral polio and measles vaccines, then a 33% wastage was expected.[31]
3. The cost did not include training components aimed at increasing the proficiency of public health workers in promoting the importance of Hib immunisation to parents.

Vaccine Efficacy

Vaccine efficacy after completing the vaccination schedule was set at 90% for the 3 conjugate doses.[32,33] No partial protection after the first and second dose of the vaccine was assumed; vaccine protection would be achieved after the third dose, in which case the vaccine would provide protective immunity until the fifth birthday.[34,35] Any additional protection as a result of herd immunity (resistance of a group to an attack by a disease due to the large proportion of the members of the group being immune[34,36,37]) was not considered.

Vaccine Safety and Complications

Hib conjugate vaccines have been shown to be well tolerated, with no reported serious adverse reactions.[32,38-40] Adverse reactions consist mostly of localised erythema. Because Hib vaccines would be given at the same time as DTP vaccines and because children immunised with DTP exhibit similar adverse reactions, it was assumed that no additional costs would be incurred for the treatment of this minor adverse reaction to the Hib conjugate vaccines.

Cost-Benefit Evaluations

Cost-benefit analyses were calculated using Microsoft Excel version 5.0.[22] The analyses included direct and indirect costs to the government and society (table IV). Results were reported as net benefits of the vaccination programme to the children in the birth cohort (costs less benefits). Sensitivity analyses of the estimates and assumptions in the cost-benefit analyses were conducted by altering single variables in the base case.

Results

In the absence of a preventive intervention against Hib meningitis there will be 980 new cases per year for a 100 000 birth cohort in Manila. A 3-dose Hib vaccination programme that aims to vaccinate children at ages 2, 3 and 4 months will reduce this

Table II. Total *Haemophilus influenzae* type b (Hib) meningitis costs for the 100 000 birth cohort (in Phillipine pesos[a]; PHP; 1998 values)

Cost component	Without Hib immunisation	With Hib immunisation
Costs to the government		
Initial visit to general practitioner	135 645	59 684
Hospitalisation	133 811 920	58 877 245
Special education (for children with moderate sequelae)	58 936 928	7 385 059
Total	192 884 493	66 321 988
Direct costs to society		
Transportation	3 649 731	1 605 881
Loss of income of parents (while the child is in hospital)	10 493 400	4 617 096
Hearing aid	3 656 279	1 608 763
Doctors follow-up and drugs	2 092 075	920 513
Residential care (children with severe sequelae)	85 796 103	37 750 285
Loss of income of a parent (care of children with severe sequelae)	280 406 400	123 378 820
Total	386 093 988	169 881 358
Indirect costs to society		
Loss of income (due to death and severe sequelae)	544 114 765	239 410 496
Total	**1 071 541 377**	**527 165 711**

a $US1 = PHP35 (1998 exchange rate).

Table III. Cost per child of *Haemophilus influenzae* type b conjugate vaccine administration

Variable	Cost per child (Philippine pesos[a]; PHP; 1998 values)
Vaccine (PHP150 per dose)	450.00
Swab	0.60
Disposable syringe/needle	18.00
Labour	0.20
Vaccine carrier/refrigerator	2.00
Total	**470.80**

a $US1 = PHP35 (1998 exchange rate).

number to 427 cases per year for the next 5 years, given the base case assumptions (table I). The expected outlay by the government for a vaccination programme for a 100 000 birth cohort is around PHP40 million.

The results of the cost-benefit analysis applying the base case assumptions show that the cost of implementing Hib conjugate vaccination is less than the cost of Hib meningitis to both the government and society. Net savings that are several times greater than the actual programme cost can be achieved from the societal perspective. From the government perspective, the prevention programme would produce a net saving of up to PHP39 million (table IV, base-case scenario).

Additional programme costs could potentially be eliminated if Hib vaccine is given together with DTP as a single injection. The marginal labour, syringe, needle and swab costs would become zero. The effect of this would reduce the vaccination programme costs by PHP1.76 million.

Sensitivity analysis was conducted by varying each parameter used in the model while others were held constant (table V). In choosing the upper and lower sensitivity values, the 95% confidence intervals for Hib meningitis incidence rates[1] and vaccine efficacy,[41,42] published vaccination rates[30] and recommended discount rate ranges[43] were used. Results of the sensitivity analysis showed that varying the parameters using the specified ranges did not change the cost-benefit results of the base case. Indeed, with the worst-case scenarios of 64.8% efficacy or 50% vaccination rate, the vaccine would still result in a positive cost benefit. The effect of varying the per dose cost of the vaccine on the cost/benefit ratio of the immunisation programme is shown in table VI.

Using the gross national product per capita (PHP32 000 per annum)[27] for valuing life (instead of using the minimum wage) was also used to assess the impact of patients who developed severe sequelae or died as a result of Hib meningitis. This

Table IV. Net cost of *Haemophilus influenzae* type b (Hib) vaccination in millions of Philippine pesos[a] (PHP; 1998 values) [a negative net cost indicates a saving]

Variable	Government	Societal direct benefits	Societal direct and indirect benefits
Base case[b]	–39.0	–255.4	–560.0
Efficacy			
64.8%	–22.0	–191.4	–21.54
100%	–84.8	–290.6	–639.2
Hib incidence rate per 100 000 children <5 years of age			
77.5	–24.4	–200.6	–449.0
111.6	–65.8	–354.8	–762.2
Vaccination rate			
50%	–19.6	–137.6	–304.0
95%	–39.6	–313.8	–595.6
Discount rate			
10%	–33.6	–279.0	–342.2
0%	–350.0	–2403.6	–26 539.4

a $US1 = PHP35 (1998 exchange rate).

b Base case: 90% vaccine efficacy, 95 per 100 000 incidence rate, 85% vaccination rate, 5% discount rate and 13% sequelae rate.

Table V. Effects of sensitivity analysis on the outcomes and costs of a vaccination programme per 100 000 birth cohort. Costs are in Philippine pesos[a] (PHP; 1998 values)

Variable	Cases/sequelae/death prevented per year	Cost per case prevented	Cost per sequelae prevented	Cost per death prevented
Base case[b]	553/74/61	14 400	108 200	131 200
Efficacy				
64.8%	430/58/47	18 600	138 000	170 200
100%	615/83/68	96 400	117 700	
***Haemophilus influenzae* type b meningitis incidence rate per 100 000 children <5 years of age**				
77.5	448/60/49	17 800	133 400	163 400
111.6	740/100/81	10 800	80 000	98 800
Vaccination rate				
50%	300/40/33	15 680	117 800	142 600
95%	586/79/64	13 600	113 200	139 800
Discount rate				
10%	553/74/61	14 400	108 200	131 200
0%	553/74/61	14 400	108 200	131 200

a $US1 = PHP35 (1998 exchange rate).

b Base case: 90% vaccine efficacy, 95 per 100,000 incidence rate, 85% vaccination rate, 5% discount rate and 13% sequelae rate.

would have an effect of reducing the total societal benefit from PHP560 to PHP400 million throughout the lifetime of the 100 000 birth cohort.

In the Philippines, hospital costs could vary by up to 20%.[44] Any decrease in hospital cost, however, would not be substantial enough to be able to change the result of the analysis from net savings to net costs from the government's perspective.

Discussion

The results of this cost-benefit analysis indicate that the costs generated by Hib meningitis from the societal perspective would exceed the costs associated with a vaccination programme. The Hib meningitis cost to the Philippine society (PHP520 million) is substantial enough to justify a 3-dose vaccination programme. Likewise, from the perspective of the government, Hib vaccination is also a worthwhile intervention; the costs of the programme are 35% less than the costs of Hib meningitis to the government (PHP62 million). The vaccination programme would remain cost beneficial to the government as long as the price per dose of the vaccine did not exceed PHP360.40 (break-even price).

Similar to a number of economic studies on Hib vaccination,[13,14,16,45] this study developed a model to simulate the effects of a vaccination programme in a birth cohort. However, in this study, there are differences in the epidemiological variables used. This study concentrated on Hib meningitis alone whereas other studies included other invasive infections associated with the Hib organism, such as pneumonia, epiglottitis and cellulitis. Also, the incidence rates for Hib meningitis used in this study are at least 2-fold higher than those used in the previous economic studies.

The low hospitalisation costs reported in Chile[18] are comparable with the hospitalisation costs in Manila (PHP26 000 and PHP27 200, respectively). However, because of the low Hib meningitis inci-

Table VI. Cost-benefit ratio of *Haemophilus influenzae* type b immunisation programme: sensitivity analysis at varying vaccine prices

Vaccine price (Philippine pesos; PHP)[a]	Cost/benefit ratio[b]		
	government direct cost	societal direct cost	societal indirect cost
20.00	11.73	43.47	88.94
306.40	1.00	3.72	7.57
1166.40	0.26	1.00	2.02
2359.6	2.60	0.49	1.00

a $US1 = PHP35 (1998 exchange rate).

b Total benefit divided by total cost.

dence in Chile (25 per 100 000 versus 95 per 100 000 in this analysis), a low price of Hib vaccine in Chile was required for the vaccination programme to be cost beneficial. For a 3-dose vaccine schedule, the break-even point was reached at a vaccine price of PHP66.20 in Chile compared with PHP306.40 in this study (same year of costing). Interestingly, the break-even point for the Israel Health Service[13] was reached at a vaccine price of PHP59 in spite of the relatively low incidence rate of 34 per 100 000 and hospitalisation costs being around 5-fold higher than in Chile and in Manila.

In the study from Chile, the costs of any long term care as a consequence of Hib meningitis were not measured, thus the main contributor to Hib meningitis cost was the cost of hospitalisation.[18] In countries where long term institutional care exists, long term care costs (excluding any measure of indirect costs), usually dominate Hib meningitis costs.[12,15,16,45] Long term institutional care costs for severe cases of Hib meningitis reported from different countries vary greatly from PHP1.1 to PHP4.6 million per year (1998 values).[16,20] The estimate used in this study for long term residential care was rather conservatively set at PHP12 000 per year and, therefore, long term residential care only accounted for 16% of the total Hib meningitis cost. However, if any loss of earnings of parents of children with severe sequelae were also included in estimating the costs of long term care, long term care cost would account for around 69% of Hib meningitis costs. However, this cost is still a lot less than that reported in Western countries.[14-16]

If children with disabilities were cared for in institutions rather than at home, long term care costs would then become direct costs to the government. Such an arrangement would make the vaccination programme even more favourable to the government (additional PHP197.6 million savings accruing to government welfare services).

Other than the cost of the vaccine, other studies have found that vaccine efficacy, vaccination rate, discount rate and rate of incidence are the key analytical variables.[13,14,16] This study found that although these variables were able to effect at least a 15% change from the base case cost-benefit results, only vaccine price was able to change the direction of the net benefit from a saving to a cost. Although reducing the discount rate to 0% did not affect the direction of the net benefit, net savings derived from the Hib vaccination programme increased several fold, and in the case of total societal cost, 47-fold.

The cost of administering the vaccine could be reduced if Hib conjugate vaccine in combination with DTP was used. However, administration cost is only minor compared with the cost of the Hib conjugate vaccine itself. On the other hand, if Hib conjugate vaccination was scheduled separately from DTP, the additional immunisation visits would increase costs to society due to the additional parental cost of time off work.

This study is not without some limitations. Not all benefits were included in the current analysis. The following additional benefits from the decrease in the number of cases and deaths as a result of the vaccination programme were not given any monetary valuation:

1. Reduction in parent distress, pain, and grief over his or her child having Hib meningitis.
2. Reduction in patient distress, pain, and grief associated with short and long term sequelae and death.
3. Increase in external benefits for members of society who feel gratified that their society is free from the risk of Hib meningitis.[13]

Partial protection from the vaccine after the first and second dose[23,38,46] was not considered in the analysis. Similarly, additional possible benefits of Hib immunisation which may be obtained through herd immunity, were also not considered in the analysis.[34,37] Also, the analysis of benefits of the Hib vaccination programme did not include the prevention of other Hib infections such as pneumonia. In a country where pneumonia is considered to be one of the leading causes of morbidity,[26,47,48] results of the cost-benefit analysis would only look more favourable if the benefits of preventing pneumonia were included.

Conclusion

The estimates from this analysis provide a basis for decision-makers to assess the value of immunisation against Hib meningitis in Manila, Philippines. As the baseline estimates applied in this analysis were conservative, it appears that immunisation against Hib would be a good investment from the perspective of both the government and society.

If a vaccination programme against Hib meningitis was introduced in Manila, 553 of the 980 cases per year from a birth cohort of 100 000 could be prevented at a cost of PHP56 200 per case for the 100 000 birth cohort. The net savings to government could be at least PHP39 million, and the savings to society at least PHP225 million based on a 90% efficacy rate, 95 per 100 000 incidence rate, 85% vaccination coverage and 5% discounting.

In the absence of other government projects with a higher benefit to cost result, the Philippine government should consider including Hib conjugate vaccine in its immunisation programme, since monetary benefits of such a programme well exceed the cost. However, although society could well afford to pay PHP1166 per dose (break-even price) of the vaccine, it is highly unlikely that the government would be willing to pay this high price. If the Philippine government can successfully negotiate a price equivalent to the hepatitis B vaccine negotiated price of PHP20 in the Philippines,[49] then the benefit of implementing a vaccination programme would exceed costs to government by at least PHP220 million. Because the epidemiology and costs associated with Hib meningitis vary between countries, the generalisability of the results of this study is limited.

In developing countries, any intervention should be thoroughly evaluated so as not to waste limited resources. This study has shown that there is a positive economic benefit for Manila and the Philippine society if a Hib vaccination programme is introduced. The results provide important information for the decision-making process.

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