Chula Med J Vol. 47 No. 5 May 2003

Cost estimation of hepatitis B vaccination program for health care workers of King Chulalongkorn Memorial Hospital

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Jiamjarasrangsi W, Kalayanachati A, Phancharoen S. Cost estimation of hepatitis B vaccination program for health care workers of King Chulalongkorn Memorial Hospital. Chula Med J 2003 May; 47(5): 295 - 308

Objective : *To estimate expenses of hepatitis B vaccination programs for health care workers (HCWs) of King Chulalongkorn Memorial Hospital from the administrator's perspective.*

Design : *Cross-sectional descriptive study.*

Methods : *The prevalence rates of HBV-related statuses among HCWs with different risk levels in the hospital were determined by an epidemiological study; then unit cost estimation and comparison of HBV vaccination program among four different screening alternatives were conducted based on the epidemiological data obtained previously; lastly, the total expenses of HBV vaccination programs for the whole HCWs in the hospital were estimated.*

Results : *Alternative 4 (inquiring about history of previous HBV vaccination and testing for HBs Ag and anti-HBs : if no previous history of HBV vaccination, then vaccination is given to those with negative results of both tests) had the lowest unit costs. These were 51,078 and 52,796 Bahts per 100 personnel,*

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respectively, for high/medium and low-risk groups. However, as the positive predictive value of adequate HBV immunity among HCWs with the history of prior HBV vaccination was only 76 percent, approximately 2.5 and 0.6 per 100 persons in high/medium and low-risk HCWs, respectively, might not then have adequate immunity to the disease if Alternative 4 is applied. Alternative 3 (testing for HBs Ag only, and vaccination if HBs Ag is negative) had the highest unit costs, due to the largest number of personnel who had to be vaccinated. Its unit costs were 93,410 and 90,350 Bahts per 100 persons, respectively, for high/ medium and low-risk groups. Unit costs of Alternatives 1 and 2 were quite similar to each other and slightly higher than those of Alternative 4 (55,895-56,660 and 64,115-65,390 Bahts per 100 persons, respectively, for high/medium and low-risk groups). The approximate total expenses of HBV vaccination program within the hospital ranged from 1.9 to 3.5 million Bahts when the vaccination program covers only the high and the medium-risk HCWs, depending on the choice of screening alternative. If the low-risk HCWs are included in the vaccination program, the total expenses will rise to 2.7 to 4.9 million Bahts.

Conclusions : *Vaccinating HCWs without previous history of HBV vaccination who also had negative HBs Ag and anti-HBs results was the cheapest alternative for HBV vaccination program in King Chulalongkorn Memorial Hospital, with minimal uncertain risk of future infection due to some HCWs might not have adequate immunity to the disease.*

Keywords : *Cost effectiveness, Health personnel, Hepatitis B vaccine, Occupational disease.*

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Received for publication. January 15, 2003.

วิโรจน์ เจียมจรัสรังษี, อัจฉรา กัลยาณชาติ, สุวรรณี พันเจริญ. การศึกษารูปแบบการตรวจคัดกรองที่เหมาะสม เพื่อการให้วัคซีนป้องกันโรคไวรัสตับอักเสบชนิดบีแก่บุคลากรโรงพยาบาลจุฬาลงกรณ์. จุฬาลงกรณ์เวชสาร 2546 พ.ค; 47(5): 295 – 308

วัตถุประสงค์ : *เพื่อศึกษาค่าใช้จ่ายและประมาณการงบประมาณของการให้วัคซีนป้องกันโรคไวรัสตับอักเสบชนิดบีแก่บุคลากรโรงพยาบาลจุฬาลงกรณ์กลุ่มเสี่ยงด้วยการตรวจคัดกรองแบบต่าง ๆ ในมุมมองของผู้บริหารโรงพยาบาล*

รูปแบบการศึกษา : *การศึกษาเชิงพรรณนาแบบภาคตัดขวาง*

วิธีการวิจัย : *ทำการศึกษาทางระบาดวิทยาเพื่อหาอัตราชุกของการเคยได้รับวัคซีน การมีภูมิคุ้มกัน และการเป็นพาหะของเชื้อไวรัสตับอักเสบชนิดบี ในบุคลากรโรงพยาบาลจุฬาลงกรณ์ที่มีความเสี่ยงต่อการติดเชื้อในระดับต่าง ๆ จากนั้นทำการคำนวณค่าใช้จ่ายต่อ 100 หน่วย (คน) ของโปรแกรมการให้วัคซีนป้องกันโรคที่มีวิธีการตรวจคัดกรองแตกต่างกัน 4 แบบ โดยอาศัยข้อมูลทางระบาดวิทยาที่ได้จากการศึกษาในขั้นแรก แล้วนำค่าใช้จ่ายต่อ 100 หน่วยที่คำนวณได้นี้มาประมาณการงบประมาณโครงการให้วัคซีนป้องกันโรคไวรัสตับอักเสบชนิดบีแก่บุคลากรโรงพยาบาลจุฬาลงกรณ์ทั้งหมด*

ผลการศึกษา : *พบว่าทางเลือกที่ 4 (ถามประวัติการได้รับวัคซีน จากนั้นตรวจคัดกรองเลือดด้วย HBs Ag และ Anti-HBs และฉีดวัคซีนในผู้ที่ผลการตรวจเลือด ทั้ง HBs Ag และ Anti-HBs ให้ผลลบ) มีค่าใช้จ่ายต่ำสุด (51,078 และ 52,796 บาท / 100 คน สำหรับกลุ่มเสี่ยงสูง/ปานกลางและกลุ่มเสี่ยงต่ำตามลำดับ) และทางเลือกที่ 3 (ตรวจคัดกรองเลือดด้วย HBs Ag เท่านั้น ในผู้ไม่มีประวัติเป็นพาหะหรือการได้รับวัคซีน และฉีดวัคซีนในผู้ที่ผลการตรวจเลือดให้ผลลบ) มีค่าใช้จ่ายสูงสุด (93,410 และ 90,350 บาท / 100 คน สำหรับกลุ่มเสี่ยงสูง/ปานกลางและกลุ่มเสี่ยงต่ำตามลำดับ) ส่วนทางเลือกที่ 1 (ตรวจคัดกรองเลือดด้วย HBs Ag และ Anti-HBs และฉีดวัคซีนในผู้ที่ผลการตรวจเลือดให้ผลลบ) และทางเลือกที่ 2 (ตรวจคัดกรองเลือดด้วย HBs Ag จากนั้นตรวจ Anti-HBs ในผู้ที่ผลการตรวจHBs Ag ให้ผลลบ และฉีดวัคซีนในผู้ที่ผลการตรวจเลือดทั้ง HBs Ag และ Anti-HBs ให้ผลลบ) มีค่าใช้จ่ายใกล้เคียงกัน (55,895 - 56,660 และ 64,115 - 65,390 บาท / 100 คน สำหรับกลุ่มเสี่ยงสูง/ปานกลางและกลุ่มเสี่ยงต่ำตามลำดับ) ซึ่งสูงกว่าทางเลือกที่ 4 เล็กน้อย อย่างไรก็ตาม*

เนื่องจากค่าพยากรณ์บวกของประวัติการได้รับวัคซีนครบ 3 เข็มต่อการมีภูมิคุ้มกันอย่างเพียงพอสูงเพียงร้อยละ 76 จึงมีบุคลากรประมาณ 2.5 และ 0.6 ต่อ 100 คนในกลุ่มเสี่ยงสูง/ปานกลางและกลุ่มเสี่ยงต่ำตามลำดับที่อาจไม่มีภูมิคุ้มกันต่อโรคอย่างเพียงพอหากใช้ทางเลือกที่ 4 สำหรับงบประมาณในการดำเนินการให้วัคซีนป้องกันโรคไวรัสตับอักเสบชนิดบี แก่บุคลากรของโรงพยาบาลฯกลุ่มเสี่ยงสูง/ปานกลางนั้นอยู่ระหว่าง 1.9 ถึง 3.5 ล้านบาท ขึ้นอยู่กับวิธีการตรวจคัดกรองที่เลือกใช้ หากการให้วัคซีนครอบคลุมบุคลากรกลุ่มเสี่ยงต่ำด้วยงบประมาณจะเพิ่มขึ้นเป็น 2.7 ถึง 4.9 ล้านบาท

วิจารณ์และสรุป : *โครงการให้วัคซีนป้องกันเชื้อไวรัสตับอักเสบชนิดบีที่มีการตรวจคัดกรองโดยการถามประวัติการได้รับวัคซีน จากนั้นตรวจคัดกรองเลือดด้วย HBs Ag และ Anti-HBs และฉีดวัคซีนในผู้ที่ผลการตรวจเลือด ทั้ง HBs Ag และ Anti-HBs ให้ผลลบ จะมีค่าใช้จ่ายในการดำเนินการต่ำที่สุด แต่อาจมีบุคลากรจำนวนหนึ่งมีความเสี่ยงต่อการติดเชื้อในอนาคตบ้าง เนื่องจากพบว่าผู้ที่มีประวัติได้รับวัคซีนครบ 3 เข็มก่อนหน้านี้แล้วจำนวนหนึ่ง อาจจะยังไม่มีภูมิคุ้มกันต่อโรคอย่างเพียงพอ*

Hepatitis B (HBV) has been the most common and severe occupational infectious disease of health care workers (HCWs).[1] Since a safe and effective vaccine became available in 1981, vaccination and verification of immunity have become major tasks within occupational health care services for HCWs. Many countries develop their national guidelines and recommendations on HBV vaccination for HCWs. However, approaches to HBV vaccination in HCWs vary in different countries. In some countries (e.g. Germany) a HCW is tested for anti-HBc prior to basic vaccination, while in the other countries (e.g. the United States and the United Kingdom) serological tests are not performed before basic vaccination of HCWs and all unvaccinated HCWs are offered vaccination.[1,2]

In Thailand, where the prevalence of HBV infection is high, no uniform approach to HBV vaccination in HCWs has yet been recommended. However, two approaches have been proposed. Kamolratanakul and Pooworawan recommended that test for HBs Ag and anti-HBs in unvaccinated HCWs and vaccination of those with negative for HBs Ag and anti-HBs was the most cost effective practice.[3] Chongsuvivatwong proposed four strategies for the prevention of occupational hepatitis B infection, the cost-effectiveness of which depends on the prevalence of exposed personnel, the cost and sensitivity of diagnostic test, and the cumulative risk.[4]

For such a large organization as King Chulalongkorn Memorial Hospital with nearly 6,000 personnel a hepatitis B vaccination program for its entire staff can be very expensive. More inputs concerning the cost effectiveness of different HBV screening options are thus needed before reaching the final conclusion on the most appropriate vaccination program. The present pilot study is aimed to estimate the cost of Hepatitis B vaccination program for HCWs of King Chulalongkorn Memorial Hospital from perspective of the hospital administrator.

Materials and Methods

Regarding the present expenses estimation, three steps of the procedure were carried out: **Step1** an epidemiological study to determine the prevalence rates of HBV carrier, natural immunity to HBV, and previous HBV vaccination among HCWs with different risk levels in the Hospital; **Step 2** unit cost estimation and comparison of HBV vaccination program among four different screening alternatives as proposed by Kamolratanakul and Pooworawan,[3] based on the epidemiological data obtained from the first step, and; **Step 3** total expenses estimation of HBV vaccination program for the entire HCWs of the hospital.

Step 1: Epidemiological Study

As a part of infectious disease control and occupational health service activities within King Chulalongkorn Memorial Hospital, a cross-sectional survey was conducted among the HCWs with three different occupational HBV risk levels. HCWs with high HBV risk work in patient care areas such as wards and operating theaters. Those with medium HBV risk work in supportive units but may contact patients' blood and body fluids via used cloths and medical devices. Low HBV risk HCWs were administrative and maintenance personnel. Sample of 339 were purposively selected from those who participated in the annual health checkup in April 2002 (sampling units were work areas/sections/wards, and

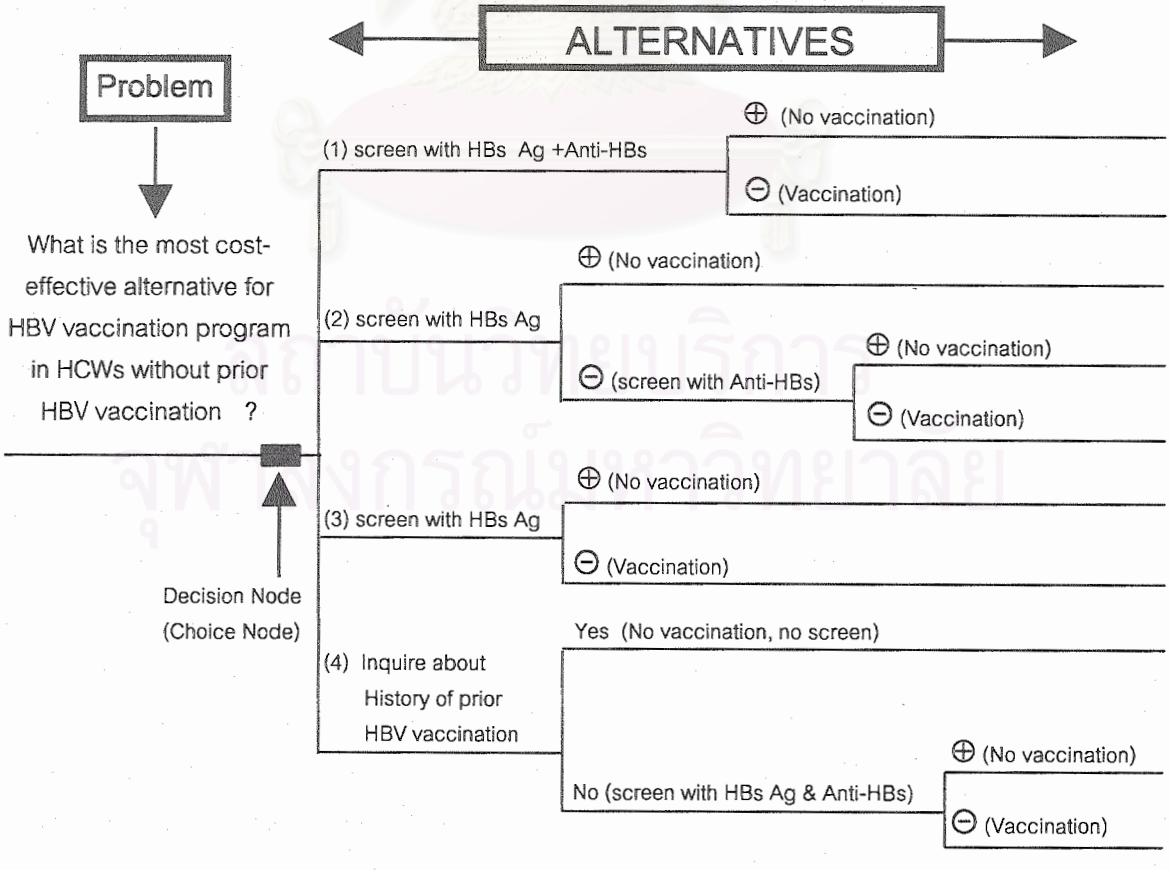
all personnel in the selected work areas/sections/wards who participated in the annual check-up were recruited). High HBV risk HCWs included 77 personnel from 3 operating theaters (general surgery, orthopedics, and neurosurgery) and 102 personnel from 4 internal medical wards. Medium HBV risk HCWs were 45 personnel from central supply and laundry room. And low-risk HCWs were 117 personnel from administrative and maintenance sections of the hospital. Sera of all these personnel were analyzed for HBs Ag and anti-HBs by enzyme-linked immunosorbent assay (ELISA) at the laboratory of the Department of Microbiology, Faculty of Medicine, Chulalongkorn University.

Data about personal demographics, history of HBV illness and vaccination status of these personnel were obtained from computerized occupational health database of the hospital.

Overall and group-specific prevalence rates of HBV carrier, HBV immunity, and previous HBV vaccination among these HCWs were analyzed and presented in percentages. Positive predicting values of the history of HBV vaccination as inferred to adequate HBV immunity were also analyzed.

Step 2: Unit Cost Estimation

The epidemiological data obtaining from Step 1 were then utilized in the unit cost estimation of HBV vaccination program with 4 different screening alternatives according to the study of Kamolratanakul and Pooworawan (Figure1).[3] Alternative 1 refers to testing for both HBs Ag and anti-HBs and vaccinating



(Modified from Kamolratanakul & Pooworawan's study)

Figure 1. Alternatives for HBV screening and vaccination in health care workers (HCWs).

all those with negative results to both tests. Alternative 2 refers to testing for HBs Ag and then anti-HBs, if HBs Ag is negative. If anti-HBs is also negative, then the vaccination is necessary. Alternative 3 means testing for HBs Ag only, and vaccination if HBs Ag is negative. Alternative 4 refers to inquiring about the history of previous HBV vaccination and testing for HBs Ag and anti-HBs if no history of previous HBV vaccination, then vaccinating those with negative results to both tests.

To simplify the calculation procedures, service charges for HBs Ag & Anti-HBs tests and hepatitis B vaccination— rather than actual materials/supplies and labor costs— were used in the unit cost estimates. These unit costs were estimated per 100 personnel, separately for high/medium and low-risk groups. And the calculation formula for different alternatives are as followed:

Alternative 1

Unit cost per 100 personnel

= [100 x (Cost of HBs Ag test + Cost of anti-HBs test)]
+ [100-(% Carrier + % Immuned)] x Vaccine cost
... (Formula 1)

Alternative 2

Unit cost per 100 personnel

= [100 x Cost of HBs Ag test] +[(100- % Carrier) x (anti HBs test)]
+ [100-(% Carrier +% Immuned] x Vaccine cost
... (Formula 2)

Alternative 3

Unit cost per 100 personnel

= [100 x Cost of HBs Ag test] +[(100- % Carrier) x Vaccine cost] ... (Formula 3)

Alternative 4

Unit cost per 100 personnel

= [(100 – % Previous vaccination) x (Cost of HBs Ag test + Cost of anti-HBs)]
+ [(100- % Previous vaccination - % Carrier–{(100 - % Previous vaccination)
x % Natural immunity among those unvaccinated)}]
x Vaccine cost ... (Formula 4)

where

% Carrier = 5.1 % (11/214) for high/medium-risk group(table 2)
= 8.5 % for low-risk group (table 2)

% Immuned = 57.5 % (123/214) for high/medium-risk group (table 2)
= 44.4 % for low-risk group (table 2)

% Previous vaccination = 10.3 % (22/214;3 doses) for high/medium-risk group (table 2)
= 2.6 % for low-risk group (table 2)

% Natural immunity = 56.6 % (116/205) for all risk groups (table 3)

Cost of HBs Ag test = 80 Bahts

Cost of anti-HBs test = 150 Bahts

Vaccine cost = 900 Bahts

Step 3: Total Cost Estimation

The numbers of the hospital's HCWs in Year 2000 were utilized in the total cost estimation of HBV vaccination program. The total number of 5,282 HCWs were categorized into 3,698 and 1,584 HCWs, respectively, for high/medium and low-risk groups based on professional classifications. High/medium-risk professions included physicians, dentists, dental assistants, registered nurses, nurse aids, practical nurses, medical scientists, assistant medical scientists, laboratory technicians, assistant laboratory

technicians, rehabilitation personnel, x-ray technicians, assistant x-ray technicians, medical technicians, midwives, patient-transfer laborers, medical ward laborers, laundry workers, and mortuary workers. Low-risk professions included pharmacists, assistant pharmacists, physical therapists, speech therapists, occupational therapists, social workers, health educators, nutritionists, cooks, nurse nutritionists, psychologists, clerk and administrators, cashiers, public relations, data entry clerks, personnel, programmers, store-room keepers, medical device store-room keepers, statisticians, children caregivers, engineers, mechanics, machinists, artisians, craftmen, masons, carpenters, drivers, general laborers, gardeners, housekeepers, tailors, and watchmen.

Unit costs for 4 alternatives in step 2 were then utilized in the total cost estimates of HBV vaccination program for HCWs of King Chulalongkorn Memorial Hospital by applying the numbers of 3,698 and 1,584 HCWs, respectively, for high/medium and low-risk groups.

Results

Epidemiological Study Results

Majority of the subjects in the high and the medium-risk groups were female registered nurses, assistant nurses, and nurse personnel, while those in low-risk group were male engineers and mechanics, laborers, and office workers (Table 1).

HBV carriers and immunity rates among the high and the medium-risk groups were quite similar and ranged between 4.7-5.3 percent for carrier rates and 50.5-62.8 percent for HBV immunity rates (Table 2). However, previous HBV immunization rates among these 2 groups were different: 23.6-27.3 percent (complete and incomplete 3 doses) for high risk group and 11.6 percent for the medium-risk group.

In low-risk group the HBV carrier rate was 8.5 percent, which was higher than those in high and medium-risk groups. Its previous HBV immunization and immunity rates were 6.0 and 44.4 percents, respectively, which were lower than those in the high and the medium-risk groups (Table 2).

Table 1. Sample characteristics.

Risk Level	# (F /M) (person)	Age (yrs) $\bar{X} \pm SD$	Professional group					
			Nurse	Nurse aid	Administration	Engineer	Laborer	Other
High risk group								
Operating rooms	77 (65/12)	37.5 ± 10.0	38	27	-	-	12	-
Wards	102 (95/7)	37.1 ± 10.4	43	53	1	-	5	-
Medium risk group								
Supply/laundry	45 (33/10)	44.7 ± 10.2	2	21	9	3	7	1
Low risk group								
Administration	117 (14/103)	44.6 ± 8.7	-	-	18	66	33	-
Total	339 (207/132)	40.9 ± 10.2	83	101	28	69	57	1

Table 2. Prevalence rates of HBV carrier, prior vaccination, and natural immunity among selected groups of HCWs in King Chulalongkorn Memorial Hospital.

Risk Level	Number (person)	Prevalence [#(%)]		Prevalence of prior HBV vaccination [#(%)]			
		HBV carrier (+ve HBs Ag)	HBV Immunity (+ve Anti HBs)	Complete (3 shots)	Incomplete (<3 shots)	Unknown*	Total
High risk group							
Operating rooms	72	4 (5.3%)	45 (59.2%)	9 (11.7%)	4 (5.2%)	4 (5.2%)	17 (23.6%)
Wards	99	5 (5.1%)	51 (50.5%)	11 (10.8%)	-	16 (15.7%)	27 (27.3%)
Medium risk group							
Supply/laundry	43	2 (4.7%)	27 (62.8%)	2 (4.86%)	3 (7.1%)	-	5 (11.6%)
Low risk group							
Administration	117	10 (8.5%)	52 (44.4%)	3 (2.6%)	1 (0.9%)	3 (2.6%)	7 (6.0%)
Total	337	21 (6.2%)	175 (51.9%)	25 (7.4%)	8 (2.4%)	23 (6.8%)	56 (16.6%)

** Positive history of prior HBV vaccination but unable to remember the number of shot*

In the analysis on the history of previous HBV vaccination as a predictor of immunity to the pathogen (positive predictive value; PPV), adequate HBV immunity was inferred from the positive anti-HBs test result. It was found that the PPV of history of either complete (3 doses) or incomplete (less than 3 doses) HBV immunization was only 70.0 percent, while the PPV of history of complete 3 doses HBV vaccination rose to 76.0 percent (Table 3).

For those without previous HBV vaccination history, the natural immunity rate was 56.6 percent (Table 3).

Unit Cost Estimates

In the calculations of unit costs of HBV vaccination program with 4 different screening alternatives, variables in Formulas 1 to 4 (in Materials and Methods section) were substituted by relevant epidemiological data previously obtained, separately for high/medium and low-risk groups. The results were shown in Tables 4 and 5, respectively, for high/medium and low-risk groups. Alternative 4 (inquiring for the history of previous HBV vaccination and testing for HBs Ag and anti-HBs if no previous HBV vaccination, then vaccinating those with negative results to both tests) had the lowest unit costs. These were 51,078 and 52,796 Bahts per 100 personnel, respectively, for high/medium and low-risk groups. Alternative 3 (testing for HBs Ag only, and vaccinating if HBs Ag is negative) had the highest unit costs, due to the largest number of personnel who had to be vaccinated. Unit costs of Alternatives 1 and 2 were quite similar to each other and a little bit higher than those of Alternative 4 (Tables 4 and 5).

Total Cost Estimation

Based on the numbers of 3,698 and 1,584 personnel, respectively, for high/medium and low-risk HCWs in King Chulalongkorn Memorial Hospital, the total costs of HBV vaccination program within the

Table 3. Positive predictive value for adequate HBV immunity (+ve Anti HBs) among the HCWs who had history of prior HBV vaccination (include only those HCWs with -ve HBs Ag results).

	History of prior HBV vaccination			
	Yes*	No	Total	
Anti HBs result				
+ ve	38	116	154	Positive predictive value = 38 / 54 = 70.0 %
- ve	16	89	105	
Total	54	205	259	

*included both complete(3 shots) and incomplete (<3shots) HBV vaccination

	History of prior HBV vaccination			
	Yes*	No	Total	
Anti HBs result				
+ ve	19	116	135	Positive predictive value = 19 / 25 = 76.0 %
- ve	6	89	95	
Total	25	205	230	Rate of natural HBV immunity = 116 / 205 = 56.6 %

* included only those with complete (3 shots) HBV vaccination

Remark: included only those HCWs with complete data

Table 4. Cost per 100 person(Baht) of HBV vaccination program for high/medium risk HCWs group in King Chulalongkorn Memorial Hospital.

Alternative	Vaccine cost (฿900/person x # persons)	HBs Ag cost (฿80/person x # persons)	Anti-HBs cost (฿150/person x # persons)	Total (Bahts)
1. Screen with HBs Ag and Anti-HBs	900 x 37.4= 33,660	80 x 100= 8,000	150 x 100= 15,000	56,660
2. Screen with HBs Ag, follow by Anti-HBs	900 x 37.4= 33,660	80 x 100= 8,000	150 x 94.9= 14,235	55,895
3. Screen with HBs Ag only	900 x 94.9= 85,410	80 x 100= 8,000	None	93,410
4. Inquire about prior HBV vaccination	900 x 33.8= 30,447	80 x 89.7= 7,176	150 x 89.8 = 13,470	51,078

Remark: HBs Ag and Anti HBs costs are 80 and 150 Bahts respectively
 # persons = number of persons

Table 5. Cost per 100 person(Baht) of HBV vaccination program for low risk HCWs group in King Chulalongkorn Memorial Hospital.

Alternative	Vaccine cost (฿900/person x # persons)	HBs Ag cost (฿80/person x # persons)	Anti-HBs cost (฿150/person x # persons)	Total (Bahts)
1. Screen with HBs Ag and Anti-HBs	900 x 47.1= 42,390	80 x 100= 8,000	150 x 100= 15,000	65,390
2. Screen with HBs Ag, follow by Anti- HBs	900 x 47.1= 42,390	80 x 100= 8,000	150 x 91.5= 13,725	64,115
3. Screen with HBs Ag only	900 x 91.5= 82,350	80 x 100= 8,000	ไม่มี	90,350
4. Inquire about prior HBV vaccination	900 x 33.8= 30,394	80 x 97.4= 7,792	150 x 97.4= 14,610	52,796

Remark: HBs Ag and Anti HBs costs are 80 and 150 Bahts respectively
 # persons = number of persons

Hospital were presented in Table 6. The approximate total costs ranged from 1.9 to 3.5 million Bahts when the vaccination program covers only the high and the medium risk HCWs, depending what screening alternative was selected. If the low-risk HCWs are also included in the vaccination program, the total costs rose to 2.7 to 4.9 million Bahts.

Discussion

Hepatitis B vaccination has been proved to be efficacious and safe for use, particularly in high-risk HCWs. Although only a few countries (e.g. the United States and Canada) have legally mandated hepatitis B immunization for all HCWs performing exposure-prone procedures, [5,6] many countries—particularly in Europe—have national policies for recommendations concerning the practice. [1,7] However, these HBV vaccination policies have differed from country to country due to different risks of exposure to the hepatitis B virus. In the United States, HBV vaccination is mandatory to all employees with potential occupational exposure to blood and body fluids. [5] In Scandinavia, vaccination has mainly been recommended for healthcare workers with frequent blood contact, while in Germany and in France vaccination has been recommended for all healthcare workers with patient contact. [7] In Italy, all healthcare workers have been considered a risk group, and vaccination is recommended for all newly recruited workers and students. As mentioned previously in the introduction, screening approaches for HBV vaccination in these countries also vary.

In Thailand, Chongsuvivatwong had conducted cost effectiveness analysis in 1989 of four feasible

Table 6. Estimated budget (Baht) of HBV vaccination program for the entire HCWs in Chulalongkorn Memorial Hospital.

Alternative	Expenditure for high/medium risk group Bahts/ 100 persons x (number of persons /100)	Expenditure for low risk group Bahts/ 100 persons x (number of persons /100)	Total (Bahts)
1. Screen with HBs Ag and Anti-HBs	56,660 x (3,698/100)= 2,095,287	65,390 x (1,584/100)= 1,035,778	3,131,064
2. Screen with HBs Ag, follow by Anti-HBs	55,895 x (3,698/100)= 2,066,997	64,115 x (1,584/100)= 1,015,582	3,082,579
3. Screen with HBs Ag only	93,410 x (3,698/100)= 3,454,302	90,350 x (1,584/100)= 1,431,144	4,885,446
4. Inquire about prior HBV vaccination	51,078 x (3,698/100)= 1,888,858	52,796 x (1,584/100)= 836,296	2,725,153

Remark: HBs Ag and Anti HBs costs are 80 and 150 bahts respectively

High/medium risk professions included physician, dentist, dental assistant, registered nurse, nurse aid, practical nurse, medical scientist, assistant medical scientist, laboratory technician, assistant laboratory technician, rehabilitation personnel, x-ray technician, assistant x-ray technician, medical technician, midwife, patient transfer laborer, medical ward laborer, laundry worker, and mortuary worker.

Low risk professions included pharmacist, assistant pharmacist, physical therapist, speech therapist, occupational therapist, social worker, health educator, nutritionist, cook, nurse nutritionist, psychologist, clerk and administrator, cashier, public relation, data entry clerk, personnel, programmer, store-room keeper, medical device store-room keeper, statistician, children caregiver , engineer, mechanic, machinist, artesian, craftsman, mason, carpenter, driver, general laborer, gardener, housekeeper, tailor, watchman.

strategies for the prevention of hepatitis B accidental inoculation among hospital personnel: (1) perform anti-HBc testing in all personnel, then vaccinate those with negative anti-HBc; (2) perform the test in all personnel, but maintain a confidential file of the test result. Following an accidental exposure, hospital administrators refer to the file to determine the marker status of the individual. Anti-HBc negative individuals receive post-exposure immunization; (3) perform no diagnostic test, but administer hepatitis B immunoglobulin following all accidental inoculations with or without subsequent vaccination of the inoculees and; (4) vaccinate all personnel without any screening test. [4] The average cost for each strategy depends on the prevalence of the exposed personnel, the cost and sensitivity of the diagnostic test, and the cumulative risk. The author claimed that if the price of vaccine is USD 10 or lower, the vaccination without screening test will cost least. If the cumulative risk is lower than 1 in 28, the cheapest strategy will be post-

exposure immunization alone, even with vaccination. And if the cumulative risk is higher than 1 in 2.5, the screening with anti-HBc followed by vaccination will be the most cost effective.

In 1998, Kamolratanakul and Pooworawan had conducted cost-effectiveness analysis of four alternatives of HBV vaccination program for medical students by basing on relevant secondary epidemiological data about hepatitis B related statuses for Thai population (details of these four alternatives are outlined in Figure 1, excepted that the anti-HBc was used in Alternatives 2 and 3 in stead of the anti-HBs).[3] The authors claimed that testing for HBs Ag and anti-HBs in unvaccinated HCWs and vaccinating those with negative for HBs Ag and anti-HBs was the most cost effective practice.

In this report, we estimated the cost of Hepatitis B vaccination program for HCWs of King Chulalongkorn Memorial Hospital based on actual epidemiological data which were obtained by a real survey among the target population. We followed the similar analytical procedures as conducted by Kamolratanakul and Pooworawan. [3] However, we used anti-HBs rather than anti-HBc test in Alternative 2 and 3. Snyder *et al.* conducted a study in the US and reported that 40 percent of healthcare workers with positive anti-HBs did not have positive anti-HBc. They then suggested that the optimal prevaccination screening program in this population would rely on anti-HBs rather than anti-HBc test.

As we used the service charges for HBs Ag& anti-HBs tests and hepatitis B vaccination rather than the actual materials/supplies and labor costs in the cost calculations, our study overestimated of the vaccination program expenses to a certain amount. The degree of this overestimate depends largely on the discrepancies between service charges and actual costs of HBs Ag & anti-HBs tests, which vary in different hospital facilities. In large hospitals, actual costs of HBs Ag & anti-HBs tests can be only a half (or less) of their service charges.

We also found that the test for HBs Ag and anti-HBs in unvaccinated HCWs and vaccinating those with negative for HBs Ag and anti-HBs (Alternative 4) needed the lowest cost. The total cost for this alternative would be approximately 1.9 million Bahts when the vaccination program that covers only the high and the medium-risk HCWs, and 2.7 million Bahts if low-risk HCWs are also included. However, as the positive predictive value of adequate HBV immunity among HCWs with the history of prior HBV vaccination was only 76 percent, a number of HCWs (among those who have the history of prior HBV vaccination) might not then have adequate immunity to the disease if Alternative 4 is applied. This would be 2.5 and 0.6 per 100 persons [prevalence rate of prior HBV vaccination x (100 - % positive predictive value)] for the high/medium and low-risk HCWs, respectively. And the actual number of those with inadequate HBV immunity in the hospital would be 96 (3,698 x 2.5 percent) and 9.5 (1,584 x 0.6 percent) persons, respectively, for these 2 HCWs groups.

Seriousness of the risk of future occupational HBV infection for these HCWs with inadequate immunity depends on the cause of negative anti-HBs results. If this was due to their non-response to the vaccination or their fault memory about prior HBV vaccination (that is, they had not been HBV vaccinated but misunderstood that they had), the risk will be serious, because they do not at all have immunity

against HBV infection. However, if it was due to the decline of their HBV antibody level over time after their initially response to HBV vaccination, the risk will be less serious. It had been reported that these persons still had adequate immunity against the HBV.[9]

In case that the risk or uncertainty cannot be tolerated, Alternatives1 (testing for both HBs Ag and anti-HBs and vaccinating all those with negative results to both tests) or 2 (testing for HBs Ag and then anti-HBs if HBs Ag is negative, if anti-HBs is also negative, then vaccination is necessary) might be more appropriate, with slightly increased cost or budget.

Acknowledgement

The authors acknowledged Professor Pirom Kamolratanakul for his generous advice. This project was funded by King Chulalongkorn Memorial Hospital.

References

1. Hasselhorn HM. Hepatitis B and D. In: Hasselhorn HM, ed. Occupational Health for Health Care Workers: A Practical Guide. Amsterdam: Elsever Science, B.V. 1999: 58 - 61
2. Centers for Disease Control and Prevention. Guideline for Infection Control in Health Care Personnel 1998. Centers for Disease Control and Prevention (CDC), Public Health Service, U.S. Department of Health and Human Services, 1998
3. ภิรมย์ กมลรัตนกุล, ยง ภู่วรวรรณ. ควรฉีดวัคซีนป้องกันไวรัสตับอักเสบชนิดบีแก่นิสิต/นักศึกษาแพทย์หรือไม่ ? แพทยสภาสาร 2541 เมษายน-มิถุนายน; 27(2): 93 - 104
4. Chongsuvivatwong V. A simplified financial cost-effectiveness analysis of programs for prevention of hepatitis B accidental inoculation among hospital personnel in Thailand. Southeast Asian J Trop Med Public Health 1989; 20(2): 189 - 93
5. Herman AM, Jeffress CN. Occupational Exposure to Bloodborne Pathogens Precautions for Emergency Responders. Occupational Safety and Health Administration [online]. 1998 [cited 2003 Jun 17]: 1 – 43. Available from : URL: http//:www.osha.gov/Publications/osha3130.pdf
6. Health Canada, LCDC. Proceedings of the Consensus Conference on Infected Health Care Workers: Risk for Transmission of Bloodborne Pathogens. *Can Commun Dis Rep* [online] 1998 Jul [cited 2003 Jun 17]; 24 Suppl 4: [I-iii, 1-25; I-iii, 1-28] Available from:URL: http://www.hc-sc.gc.ca/pphb-dgspsp/publicat/ccdr-rmtc/98vol24/24s4/index.html
7. Iwarson S. Strategies for immunization against hepatitis B in western Europe. Vaccine 1993; 11 Suppl 1: S18 - 20
8. Snydman DR, Munoz A, Werner BG, Polk BF, Craven DE, Platt R, Crumpacker C, Ouellet-Hellstrom R, Nash B, Grady GF, et al. A multivariate analysis of risk factors for hepatitis B virus infection among hospital employees screened for vaccination. Am J Epidemiol 1984 Nov; 120(5): 684 - 93
9. Wainwright RB, Bulkow LR, Parkinson AJ, Zanis C, McMahon BJ. Protection provided by hepatitis B vaccine in a Yupik Eskimo population - results of a 10-year study. J Infect Dis 1997 Mar;175(3): 674 - 7