Hepatitis B vaccination: the cost effectiveness of alternative strategies in England and Wales

Punam Mangtani, A J Hall, C E M Normand

Abstract

Objective – To assess the cost effectiveness of adding universal hepatitis B vaccination in infancy or pre-adolescence to a policy of selective vaccination of at risk groups.

Design – Costs of a selective policy and additional costs of universal vaccination policies were estimated from costs of vaccine delivery and published data on target populations. Additional years of life gained were calculated for each policy by applying life tables to estimates of mortality attributable to hepatitis B.

Setting – England and Wales.

Results – Compared with no vaccination, vaccination in infancy was the most cost effective followed by vaccination in pre-adolescence. Selective vaccination was the least effective (cost per year of life gained £2568, £2824, and £8564 respectively). Adding vaccination in infancy or at pre-adolescence to a selective policy cost £1537 or £1658 per year of life gained. Discounting years gained in the future at 6% per annum, however, made pre-adolescent vaccination more cost effective than infant or selective vaccination (£51 817, £94 821, and £124 779 per discounted year of life gained). Adding pre-adolescent vaccination to a selective policy cost £32 125 per discounted year of life gained and infant vaccination, £77 085.

Conclusions – Universal vaccination against hepatitis B was more cost effective than selective vaccination in a low prevalence country. Discounting future health gain, however, made universal infant vaccination least cost effective than universal pre-adolescent vaccination. If future health gained is as important as present gain the addition of universal vaccination to a selective policy is equivalent to the cost per quality adjusted year of life from renal transplantation or breast cancer screening.

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Although infection with Hepatitis B virus can be asymptomatic, it is also associated with disease ranging from acute hepatitis (and rarely fulminant liver failure) to chronic liver disease and primary liver cancer. Hepatitis B vaccine has an efficiency >90%,¹² no serious side effects, and has been available since the early 1980s.

Countries of low endemicity, including the United Kingdom where most transmission oc-

curs in adulthood, have implemented selective vaccination policies aimed at adults in high risk categories combined with selective or universal antenatal testing and provision of vaccination to babies born to women who are hepatitis B carriers. High risk categories include close contacts of people with the virus, injecting drug users, those who frequently change sexual partners, and people occupationally or therapeutically exposed to blood.

Effective vaccine delivery with a selective policy is difficult. The World Health Organization has suggested that all countries should re-examine their hepatitis B control strategies.³ In the United States and Italy universal vaccination in infancy is now recommended,^{4,5} and there is support for a similar change in Canada.⁶

The benefits of vaccination against hepatitis B are not easily perceived in countries of low endemicity. This is partly because of the low prevalence of carriage and hence risk of infection and partly because of the long lag between infection and the uncertain probability of chronic liver disease or cancer. Economic considerations probably also play a part in the continuation of a selective policy in the UK and other low prevalence countries.

We therefore examined the relative cost effectiveness of the current selective policy versus universal vaccination in infancy or pre-adolescence. It is likely that selective vaccination of adults will continue for some time so the incremental cost effectiveness of adding either of the two universal vaccination policies to selective vaccination was also estimated.

Method

OVERALL DESIGN

Cost effectiveness was calculated as cost per year of life gained. The number of years of life gained from each policy was derived from cause specific mortality data. An estimate could be made of the fraction of deaths from liver disease attributable to hepatitis B as the relative risk of disease from chronic carriage and the probable range of prevalence of infection are known to a sufficiently accurate level.⁷ This method of working backwards from mortality data to measure the potential effect of interventions was considered more robust. An alternative approach would be prospective modelling of the natural history of the illness, but this was not used because of the uncertain estimates of the probability of disease in those infected in adulthood. The published data on risk of chronic carriage in adulthood refer to Eskimos or to patients admitted to hospital with acute

Department of
Epidemiology and
Population Studies,
P Mangtani
A J Hall

Department of
Public Health
and Policy
London School of
Hygiene and
Tropical Medicines,
Keppel Street,
London, WC1 7HT
C E M Normand

Correspondence to:
Dr P Mangtani.

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Table 1 Annual costs in (£s) of treatment per course of vaccine in each policy

Type of cost	Policy		
	Selective	Universal, infant	Universal, pre-adolescent
Vaccine dose	9.82	7.36	7.36
Staff cost per dose (staff time)	4.2(15)	1.4(5)	2.8(10)
Other maintenance syringe per dose	0.031	*	0.031
Needle per dose	0.0116	*	0.0116
Cost of one dose	14.08	8.76	10.21
Cost of third pre-adolescent dose			8.81
Fixed costs per dose (only for drug clinic pts)	1		
Indirect costs of attending for second or third dose	12.50	0	0
Screening test for HBsAb/antiHBc	5	0	0
Cost per course (non-drug clinic patients in selective policy)	72.23	26.29	29.23

* The cost of needles and syringes are not included in infant vaccination programme as we assumed hepatitis B vaccine would be available combined with one of the routine infant vaccines.

hepatitis. Estimates for the risk of chronic carriage in those infected as adults vary between 4 and 10%.^{8,9} The estimates for the probability of progression to disease with carriage beginning in adulthood are subject to greater uncertainty because studies are based on small numbers of events or are biased by the restriction to hospital cases.¹⁰

The robustness of the cost effectiveness analyses of the various policies to the estimates used were examined through sensitivity analyses.

COSTS

The average time vaccination takes – including counselling and paperwork – was estimated from interviews with staff who usually provide vaccination in the UK: nurses, general practitioners, and community paediatricians. The costs of nurses’ time were estimated from middle grade salary scales current in 1993 (district nurse or health visitor level). The core assumption on vaccine cost was based on costs from the manufacturers in the UK for bulk purchases: £9.82 per adult dose and £7.36 for each infant and pre-adolescent dose, with three doses needed to complete the full course. Since this cost is likely to fall if universal vaccination is implemented, a range of costs down to £0.50 per dose was also examined. Other variable costs are shown in Table 1. (The numbers given in the tables have been rounded but exact numbers were used in subsequent calculations.)

In countries where universal vaccination is being implemented, booster vaccination is not included at present⁴ and is not thought to be necessary within a strategy of universal vaccination. Cohort studies of vaccinated infants, children, and adults followed up serologically and clinically for almost 10 years suggest that if there is exposure to infection, asymptomatic infection may occur, but this does not result in acute hepatitis or chronic carriage except in those who have not successfully seroconverted after initial vaccination.¹¹

Overhead costs and social costs incurred in providing and attending for vaccination in infancy and pre-adolescence were not included as current facilities and patient visits, or school attendance for a pre-adolescent policy, would

be used. For the selective policy, although the first dose would be given opportunistically, attendance for second and third visits will have indirect costs. This was estimated as equivalent to an hour of time per adult patient for the second and third doses, at a cost of £12.50 per hour. The opportunity costs for services targeting drug users were also included as a new clinical service would be needed in addition to the more usual role of providing counselling or detoxification. Overheads for equipment such as refrigerators, waste disposal, and storage space for drug clinics and cold chain were estimated as an extra cost of £1 per dose (on the assumption that £500 per clinic would be needed for equipment lasting five years, with an average of two to three doses given each week.)

Cost savings to the health service in reducing the incidence of acute and chronic liver disease and indirect costs (form work related loss of income, or the monetary value of lives lost) were not included. Some cost-benefit analyses in the USA have included these savings but not the extra costs of health services and social care of those who remain alive. Health sector savings would be offset both by the cost of services for people who live longer, with the replacement of hepatitis B by other terminal diseases. The net effect is not easily calculable and so was not included. This is a problem in many cost-effectiveness studies, and requires further research.

DESCRIPTION OF THE VARIOUS VACCINATION POLICIES

It was assumed that the time schedule for the three doses of hepatitis B vaccine in infancy was integrated with the other infant vaccinations using a combined preparation with *Haemophilus influenzae* B vaccine or the with diphtheria/polio/tetanus vaccine. Thus, only two intramuscular injections for the full infant vaccination schedule would be given at each visit. Extra nursing time was needed to provide the counselling and clerical work specifically for the hepatitis B vaccine. Vaccine uptake was assumed to be 92%, as is presently achieved for routine infant vaccinations.¹²

It was assumed that one dose in pre-adolescence would be administered at the same time as tuberculin skin testing before BCG administration and that the remaining two doses would be given alone, since the current rubella vaccination programme will end when the cohort of children in the UK now being given MMR at age 18 months reaches 13 years of age. The time for administering each dose was estimated at 10 minutes for doses given alone and five minutes for the dose given with the tuberculin skin testing. Vaccine uptake was assume to be 80%, as is achieved for rubella vaccination.¹²

The cost of the selective policy was based on vaccination of all newly-presenting adults in risk categories recommended for vaccination¹³ and attending health services where vaccination would be available. The size of each population was estimated from sources given in table 2.

Table 2 Population estimates of those attending health care services for the first time per year and therefore eligible for vaccination against hepatitis B

Population	No attending	% of total	Reference nos
Gay/bisexual men attending GUM clinics*	10 000	4	40
Heterosexual men and women attending GUM clinics†	150 000	61	
New injecting drug users reported to Home Office	4 700	2	41
Health workers‡	58 000	24	42
Prisoners or people in remand, both present for more than 6 months§	16 000	6.5	43, 44
Dialysis patients (new patients accepted for transplant)	3 430	1.4	45
Haemophilia patients¶	120	0.05	46
Patients with mental handicap attending institutions**	4 280	1.5	42
Total population at risk in an enhanced selective vaccination policy	246 530	100	
Infants	677 422		47
Pre-adolescents††	670 082		

* Taking about 50%⁴⁸ attenders of genito-urinary clinics as being new attenders.
† From estimating 64%⁴² of episodes of infection noted at genito-urinary (GUM) clinics⁴⁹ were first episodes, 10% of men were gay⁴⁰ and assuming, as for gay men, half were attending for the first time.
‡ Calculated from a 10% turnover⁵⁰ of nursing, midwifery, medical, dental, and professional and technical staff as well as staff working in homes for those with mental handicap.
§ Data from 1986 indicate that a third or more of prisoners discharged re-enter custody within 2 years.⁵¹
¶ Estimated using a life expectancy of 50 years.⁵²
** Estimated assuming turnover equal to number of discharges and deaths of those staying more than 1 year.
†† Based on present life expectancy³⁰ of a birth cohort in 1991 reaching age 11 years.

The cost of one laboratory test for surface antibody or core antibody either before (gay men and drug users) or after (health care workers) vaccination was included. Vaccine uptake in gay men in a genitourinary medicine clinic focusing on vaccination has been reported to be 28%.¹⁴ Uptake in those attending drug clinics is likely to be similar, though uptake in health care workers is much higher. An overall 50% uptake in all the populations at risk was assumed.

Universal antenatal testing and protection of babies born to women carrying the virus is now recommended in the UK¹³ and is likely to be implemented no matter which other policy for hepatitis B vaccination is in operation. The effect of full implementation of this antenatal policy on the cost effectiveness of the other policies was checked.

OUTCOMES

Health gain was estimated from the incidence of deaths related to liver disease in England and Wales. Yearly average numbers of non-neoplastic liver disease deaths from 1985–90 were obtained from ICD codes 70, 570, to 573 and for hepatocellular carcinoma ICD code 155.¹⁵ The proportion of these deaths attributable to hepatitis B was estimated by calculating the population attributable risk fraction from the prevalence of carriage of the virus and relative risks of disease. In the general population prevalence of carriage is likely to be between 0.2%–0.7%, based on serological surveys in blood donors and antenatal patients.^{16–19} The relative risk of non-neoplastic liver disease in hepatitis B carriers was estimated to be 13 (95% confidence interval (CI) 9, 18) and for hepatocellular carcinoma 22 (95% CI 11, 40) in England and Wales based on an updated analysis of a blood donor cohort study.²⁰ A carrier prevalence of 0.5% gave the fraction attributable to the virus for non-neoplastic liver disease at 5.5% and for hepa-

tocellular cancer as 9.6%. These fractions were similar to the proportion of cases of liver disease due to hepatitis B infection in hospital series of white patients in Britain and the United States.^{21–23} Sensitivity analyses of these estimates were carried out by varying the prevalence estimates and using the 95% CIs on the relative risks.

As no other data were available, we used a study of patients with acute infections in the United States to estimate that 60% of carriers in the population fell into high risk groups.²⁴ Surveillance data on acute infections in England and Wales give a value of just over 50% occurring in high risk groups.²⁵

Prevalence of past infection in the people attending health services varies in relation to risk category, age group, and calendar period.^{26–28} Assuming a 10% prevalence of prior infection for the population at risk attending health services for the first time meant that 10% of deaths in the high risk groups were not prevented by a selective policy.

Utilisation rates of health services in different risk groups is very variable. Less than 20% of injecting drug users are thought to be known to any services.²⁹ We assumed that 50% of all the groups at risk would have access to health care services where vaccination would be provided. Together with the assumed overall vaccine uptake of 50% as previously described, this meant that 25% of all deaths in those in risk categories were prevented by a selective policy. The importance of more accurate health care utilisation rates was tested by sensitivity analysis.

Ninety eight per cent of all deaths occurred in those over the age of 30 years. Deaths arising before age 15 years were excluded, however, in a selective policy, and those arising before age 12 were excluded in a pre-adolescent policy. Years of life gained were calculated by applying the current UK life expectancy by age group³⁰ to the number of deaths in each age group attributable to hepatitis B and prevented by

Table 3 Cost (£s) per year of life gained with each policy using undiscounted years

Policy	Cost	Years gained	Cost per y of life gained	Addition cost per y life gained*
Selective	8 018 963	936	8564	
Universal pre-adolescent	15 668 482	5549	2824	1658
Universal infant	16 386 431	6381	2568	1537

* If introduced in addition to selective policy

each policy. For comparative purposes,³¹ years of life gained were recalculated at a discount rate of 6% per annum. This is the rate set by the Treasury as the annual return expected on investments. If a discount rate is applied to health gain an assumption is made that future health gain is worth less today than present health gain. The guidance from the Department of Health is that undiscounted health gain should be presented.³²

Results

One of the largest items of cost per fully vaccinated individual was the cost of the vaccine (table 1). The selective policy was the most expensive per vaccinated individual because of the costs of nursing time, social costs to patients for attending for subsequent doses, and laboratory tests. More nursing time was used in the selective strategy because of the need to recall patients, advise, and take blood.

Based on our acceptance of the argument that undiscounted years of life gained should be used, the results were as follows. Compared with no vaccination the selective policy was less cost effective than universal vaccination in pre-adolescence or infancy. Adding universal infant vaccination policy to a continuing selective vaccination was slightly more cost effective than pre-adolescent vaccination (table 3).

The importance of greater accuracy in determining the various cost and outcome estimates used was tested (table 4). Reducing the nursing time for pre-adolescent vaccination to five minutes from 10 minutes made this as efficient as infant vaccination, and reducing the cost of vaccine to 50 p made universal vaccination much more attractive than a selective policy. The relative ranking of the policies was, however, insensitive to the following

assumptions: reducing the nursing time required in a selective policy to five minutes; the uncertainty around the relative risk estimates for death from liver disease or hepatocellular carcinoma in hepatitis B carriers; whether all those in risk categories utilised health services; the level of vaccine uptake for all policies; the proportion of deaths occurring in the risk categories; and the proportion of the population with a prior infection. The size of the at risk population accessible by health care services in a selective policy was not important as selective vaccination only became as cost effective as a universal pre-adolescent policy if the size of the population was a third of that estimated.

With full implementation of the antenatal policy we estimated that only about 10% of all carriers would be prevented.³³ However, specific follow up of infants is required to ensure uptake of the second and third injections. The cost effectiveness of each policy was reduced slightly if 10% of carriers, and hence deaths, were prevented by universal antenatal testing and vaccination but the ranking of the policies was not changed (table 5). Nor did the prevalence of carriage of hepatitis B virus in the population affect the ranking of the policies, but the absolute cost per year of life gained by any of the policies increased in proportion to the fall in the prevalence of carriage (table 5).

There are no published studies with reliable estimates of the effects on the quality of life of chronic liver disease. Clinical judgement used for a recent economic analysis (Dusheiko and Roberts, unpublished), suggested the value of a life with chronic liver disease ranged from 0.2 to 0.9 of a full year of life depending on severity of disease. Case series data indicate that five year survival and decompensated cirrhosis can be as little as 15–40%.^{10 34 35} Median survival with a diagnosis of hepatocellular liver cancer is only six months. The effect of taking into account the improvement in the quality of life with vaccination was explored by assuming that for every death from chronic liver disease a person spent approximately three years of life beforehand with a value of 0.6 of a healthy year of life and for every death from primary liver cancer there was six months of life with a quality of only 0.2 of a healthy year of life. This reduced the cost per year of life gained from each policy only slightly, £8388 per quality adjusted life year (QALY) with a selective policy

Table 4 Sensitivity of the cost (in £s) per undiscounted year of life saved (discounted year, per life saved) with each policy to various estimates: costs of policies, changes in the relative risk of death due to hepatitis B, and health care utilisation rate.

Changes in estimates	Selective policy	Universal policy	
		Pre-adolescent	Infant
Baseline	8564 (124 779)	2824 (51 817)	2568 (94 821)
Nursing time 5 min in selective policy and 5 min in pre-adolescent policy	7566 (110 234)	2485 (45 593)	2568 (94 821)
Cost of vaccine down to 50 p	5251 (76 513)	836 (15 333)	558 (20 602)
Relative risks of mortality with HBV:			
Using lower 95% CIs	13 221 (190 638)	4359 (79 169)	3964 (144 873)
Using higher 95% CIs	5804 (85 148)	1914 (35 359)	1740 (64 704)
70% of deaths occur in risk groups, of whom 65% attend services	6423 (93 584)	2824 (51 817)	2568 (94 821)
At risk population to be vaccinated reduced to 1/2 size	2859	2824	2568
1/4 size	(93 609)	(51 817)	(94 821)

Table 5 Sensitivity analysis exploring the cost (in £s) per year of life gained of each policy with (a) the removal of perinatal transmission by universal antenatal testing and vaccination or (b) with the prevalence of carriage varying from 0.1% to 0.5%

Changes in estimates	Selective	Vaccine policy		Additional cost effectiveness	
		Pre-adolescent	Infant	Pre-adolescent	Infant
(a) In addition to universal antenatal testing and vaccination	9516	3137	2853	1843	1708
(b) Prevalence of carriage of HBV					
0.5%	8564	2824	2568	1658	1537
0.4%	10 566	3484	3168	2046	1896
0.3%	13 903	4584	4169	2692	2495
0.2%	20 577	6785	6170	3985	3692
0.1%	40 595	13 385	12 173	7861	7285

HBV = hepatitis B virus

and £2515 to £2776 per QALY for universal infant or pre-adolescent vaccination.

The results were, however, sensitive to discounting. Discounting health gain at 6% per year, reduced considerably the number of years of life gained by each policy, more so for an infant compared with a pre-adolescent policy. Pre-adolescent vaccination became the most cost effective followed by infant vaccination, with the selective policy being the least cost effective. Universal pre-adolescent vaccination added to a selective policy also became more cost effective than adding universal infant vaccination (table 6).

The cost effectiveness of universal vaccination compared with a continuing selective policy was only sensitive to the burden of disease in risk groups and health care utilisation rates in these groups in the analysis using discounted years (table 4). The cost per discounted year of life saved in a selective policy became equivalent to the cost of universal infant vaccination in two plausible scenarios. The first was if 70% rather than 60% of all diseases occurred in those at risk and if 65% rather than 50% of all those at risk who go on to get disease had attended health care services. The second scenario was if the size of the population was in fact only three quarters of that estimated. The relative cost effectiveness of pre-adolescent compared with infant vaccination in terms of discounted years of life saved remained robust to the uncertainty of the estimates used.

Discussion

If future health gained is as important as present gain³² the most cost effective policy in a low prevalence country like the UK is universal vaccination in infancy rather than in pre-adolescence. Universal infant vaccination would cost £2198 per year of life gained (converted to 1990 prices) equivalent to rental trans-

plantation which costs £2000 and breast cancer screening which costs £3000 per quality adjusted year of life gained in 1990.³² Universal vaccination also compares favourably with the current selective policy for hepatitis B vaccination which would cost £7331 per year of life saved at 1990 prices. Implementing a universal infant or pre-adolescent policy in addition to a selective policy would be equivalent in 1990 to £1316 and £1419 per additional year of life gained respectively.

Comparing a simple outcome measure of the cost per year of life saved with other health care interventions underestimates the effect of vaccination against hepatitis B. Infection as an adult results in acute symptomatic hepatitis in a third of cases, which may last for several weeks, and can carry stigma, as do other infections transmitted by sex or drugs, but is rarely fatal. Chronic infection with the virus can cause ill health from chronic persistent hepatitis and chronic active hepatitis which can last many years. These disease states can progress to cirrhosis with death being preceded by decompensation into episodic bleeding from oesophageal varices, liver failure, or peritonitis. Sufficient data are not yet available, however, to produce more than a tentative measure of these various states in the form of quality adjusted life years or in the net cost of health care and social services if patients did not die from the long term effects of hepatitis B infections. Reflecting some of the morbidity prevented in quality adjusted life years in this analysis did not affect the ranking of the efficiency of the various vaccination strategies for hepatitis B, and made vaccination only slightly more cost effective than other health care interventions. Given that the main benefits of preventing hepatitis B infection lies in extending life and not quality of life, estimates of benefits are not greatly improved by adjustment for quality of life.

We have used a retrospective approach, measuring the cost in one year of each of the policies and the future years of life gained in those vaccinated. Some of the extra benefits of vaccination are reflected in the quality of life years estimates but it is also reassuring that transmission from those vaccinated is less likely. The indirect benefits arising from this, however, will not accrue for a long time because of the large pool of infection carriers in the community.

Table 6 Cost (in £s) per year of life gained with each policy using the discount rate of 6%

Policy	Cost	Years gained	Cost per y of life gained	Additional cost per y life gained*
Selective	8 018 963	64	124 779	
Universal, pre-adolescent	15 668 482	302	51 817	32 125
Universal, infant	16 386 431	173	94 821	77 085

* If introduced in addition to the selective policy

An estimated prevalence of hepatitis B carriage in the general population of 0.5% was considered appropriate as it yielded estimates of liver disease attributable to hepatitis B that were consistent with the proportion of cases due to hepatitis B in hospital case series data of white patients.^{21–23} If the prevalence of hepatitis B carriage were lower this analysis showed that a continuing selective policy would still be relatively more expensive than the universal policies. The ranking of the cost effectiveness of hepatitis B vaccination compared with other health care interventions would, however, be affected.

The ranking of the various vaccination policies was extremely sensitive to the discounting of health gains in the future. Pre-adolescent vaccination became much more cost effective than infant vaccination. This was to be expected because of the postponement of benefits. In the UK most infections do not occur until adult life. The shorter gap between vaccination and health gain in a pre-adolescent policy means that benefits are discounted less heavily. This analysis highlights the importance of the current debate over the use of discounting in economic analyses.^{32,36} As discussed by Parsonage and Neuberger, discounting “reflects the fact that individuals generally prefer income today to income tomorrow and so expect to be compensated for any deferral, for instance by receiving a positive real rate of interest on their savings” and allows appraisal of several different health policies by “putting differently dated costs and benefits on a common footing”.³² A few researchers, however, have emphasized “the question of the tradability of health both with wealth and future health”.³⁶ For instance it is impossible to trade a year of life now for a year in the future. The second argument against discounting of health benefits is the suggestion that in fact “the private discount rate for health is zero or even negative”.³⁶ Policy makers must take a view on this debate. This analysis shows empirically the importance of showing undiscounted as well as discounted health gains, as whether or not discounting is used affects the judgement of the efficiency of vaccination in pre-adolescence or infancy.

Selective vaccination is good medical practice but seemed the least effective use of resources. The costs of a selective strategy are also likely to have been underestimated because several factors were not taken into account. These include: the possible lower vaccine efficacy in adult risk groups compared with children,³⁷ the cost of vaccinating contacts of cases and carriers, and the organisation and education required to supply and deliver the vaccine. A selective policy is difficult to implement properly because of the variety of risk groups. Effective delivery in the UK has also not yet been demonstrated.¹⁴

Universal antenatal testing instead of selective antenatal testing combined with appropriate vaccination of infants born to carrier mothers has recently been suggested for consideration.¹³ The potential maximum benefit of universal antenatal testing and vaccination of infants born to carrier mothers had only a

small effect on the attractiveness of universal vaccination against hepatitis B compared with other preventive interventions. The present day costs of universal antenatal testing would be more than three million pounds per year. With a universal vaccination policy, women would no longer need to be tested when the vaccinated cohorts reach reproductive age. These savings would not start to be seen for one or more decades and so would be heavily discounted. Even so the biases from not including the savings in our analysis would favour a selective policy. An infant vaccination programme might also reduce the need to recall about 2000 newborns to carrier mothers per year for their second and third doses as they could be provided within the routine infant vaccination schedule. Delaying the second dose from one to two months to fit in with routine vaccination, in accordance with guidelines in the USA,⁴ will not be a problem as hepatitis B is highly immunogenic in infancy and the dose interval has little effect on this.³⁸

Another possible source of bias in this analysis is that costs were based on estimates of the new population for each policy while the years of life gained were calculated from current incidence. This numerator/demoninator bias is most likely to affect the estimated cost effectiveness of a selective policy. The following factors, however, became important only if discounted years of life were used: the proportion of all deaths attributable to being in an at risk group, health care utilisation rates, and, to a lesser extent, the size of the population at risk that would be vaccinated.

The current incidence of chronic liver disease used to calculate years of life gained reflects risk of infection 10–45 years earlier. The effect of including deaths in migrants (who would not have been protected by vaccination strategies in the UK) was small since only 5% of deaths from primary liver cancer were in persons born abroad.³⁹ Both these influences on the years of life gained would have affected all hepatitis B vaccination policies equally so that the relative ranking of the policies would not be altered.

This economic analysis is based on the imperfect data currently available in low prevalence countries and highlights the further information that would help other countries including the UK in determining the most cost effective hepatitis B vaccine policy. This includes data on the burden of morbidity and mortality occurring in individuals in high risk groups, the likely utilisation rates of health care services by those in high risk groups, the acceptability of vaccination by different age groups, and operational research to assess the feasibility of introducing a pre-adolescent policy.

There are limitations to economic analyses. Costs may change. For example if, as has been suggested in countries like Canada, hepatitis B vaccination is provided in pre-adolescence with the simultaneous delivery of other programmes to promote reproductive health, the costs of a pre-adolescent hepatitis B vaccination programme will be reduced. The political and professional will, as well as the education re-

quired to change an existing vaccination programme also need to be considered. Finally factors other than optimal use of societal resources may be important. This analysis does not take into account the desirability of reaching groups already socially or economically disadvantaged, the prevention of rare occurrences of child to child transmission or removing the risk of those in contact with infectious individuals.

The current preference for a selective policy in low prevalence countries may be based on perceived economic efficiency. We have attempted an analysis of the cost effectiveness of the various vaccine policies for hepatitis B using data currently available in the UK. The analysis indicates that selective vaccination may not be the most cost effective strategy in preventing mortality, let alone morbidity, from hepatitis B and that addition of universal vaccination against hepatitis B to a selective policy may be no more expensive than some other established public health interventions.

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