A SEROEPIDEMIOLOGICAL STUDY OF HEPATITIS B AMONGST FIJI HEALTH CARE WORKERS

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Abstract. Hepatitis B immunization for health care workers is common policy in many countries where they constitute a particular at risk group. A seroepidemiological study of hepatitis B virus (HBV) in Fiji health care workers was conducted to determine whether this occupational group (or subgroups thereof) were at higher risk of infection than the general Fiji population. The purpose of this study was to ascertain whether health staff should be immunized, or whether it would be more productive to focus resources on neonatal immunization.

Blood samples were obtained from 2,639 health workers and the sera analysed by radio-immunoassay for hepatitis B surface antigen (HBsAg), and hepatitis B surface antibody (anti-HBs). Prevalence rates of HBV markers of infection were compared with those observed in the general population, from a previous population-based cluster sample survey. Approximately 70% of the health care staff participated in the study. Prevalence of total HBV markers was 24%. The rate of HBsAg was 5%. Sex and ethnic group specific prevalence rates varied. Male subjects, Fijians and "other" Pacific Islanders all experienced higher rates of infection. Rural/urban and age related trends were also observed.

Rates of infection in health staff were lower than those reported in the general population. Previous studies have indicated that most of the transmission of hepatitis B in hyperemdemic Pacific populations occurs at birth or within the next few years. There was no consistent pattern of hepatitis B infection in different occupational groups of health care workers. Certain relatively socially homogeneous subgroups of health workers were analysed separately, and among these health workers there was evidence for increased risk of infection due to exposure to blood or used hypodermic syringes, but not due to patient contact. Until health staff assume a higher risk of infection than the general Fijian population, efforts directed at community-wide control of hepatitis B continue to be the most appropriate use of resources.

INTRODUCTION

Hepatitis B virus (HBV) infection is endemic in the South Pacific region (Blumberg *et al*, 1976; Austin *et al*, 1974; Gust *et al*, 1978; Gust *et al*, 1979; Wong *et al*, 1979; Hawkes *et al*, 1981; Mazzur *et al*, 1981; South Pacific Commission Report 1981; Zhuang *et al*, 1982; Zhuang *et al*, 1983; Taylor *et al*, 1984; Williamson *et al*, 1985; Wainwright *et al*, 1986). Prevalence rates of current or past infection range from 20% to 90%, and are often above 70%. Carrier rates of hepatitis B surface antigen (HBsAg) are also high (10-15%). Prevalence of markers of infection generally increase with age, reach a peak in young adults, and decline slightly thereafter, suggesting transmission of infection at birth and during childhood. Several reports indicate maximal transmission during early childhood (Zhuang *et al*, 1983; Taylor *et al*, 1984; Williamson 1985; Leichtner *et al*, 1981; Taylor *et al*, 1989). Male infants appear to have higher surface antigen prevalence than females. The risk of chronic carriage of antigen following infection is much higher after perinatal than later exposure (Leichtner *et al*, 1981; Taylor *et al*, 1989). Despite some differences between countries, no consistent ethnic differences occur in the Pacific except in Fiji, where prevalence rates are considerably lower in Indians than in Melanesians (Zhuang *et al,* 1982).

Although HBV transmission via blood and blood products, and through sexual contact, is common in industrialized nations, other mechanisms must explain the majority of early transmission in Pacific Island countries (PICs). Vertical transmission (mother to infant at birth), and subsequent horizontal transmission through close contact and exposure to body secretions (eg saliva, nasal discharge and open wounds), are probably major mechanisms in these populations (Heathcote *et al,* 1974; Villarejos *et al,* 1974; Leichtner *et al,* 1981; Tibbs 1987; Taylor *et al,* 1989).

Studies in the United States (Lewis *et al,* 1973; Pattison *et al,* 1975; Maynard 1978; Denes *et al,* 1978; Snydman *et al,* 1984) and Algeria (Khalfa and Ardjoun, 1984) suggest that health care personnel are at greater risk of HBV infection than the general public. This is probably due to contact with blood and body secretions of HBV patients and carriers. Duration of employment (Snydman *et al,* 1984), ethnic group (Maynard, 1978; Snydman *et al,* 1984) and socio-economic status (Maynard, 1978) influence HBV prevalence among health care workers. Their high risk status vindicates use of mass immunization to protect against HBV infection. However if the background rate of infection in the community is high, as in many PICs, then little extra benefit may be derived from mass immunization of health staff.

This seroepidemiological study was conducted to evaluate the potential benefit of HBV immunization of health care workers in Fiji. The survey determined the prevalence of HBV infection in health care workers, and compared this with previously reported rates for the general Fiji population. The survey findings are presented, and the implications discussed for immunization policy of Fiji health care workers.

MATERIALS AND METHODS

The target population was all staff members of the Fiji Ministry of Health, including permanent and non-established staff, and students of the Fiji Schools of Medicine and Nursing. Information on occupation, sex, ethnic group and age were available for all permanent departmental personnel (Fiji Ministry of Health, The Prism Report, 1984).

All major health care facilities and most rural health centers and nursing stations were visited by the survey team. Several remote locations could not be reached. In some instances, staff from isolated areas were able to attend a central survey site. Whenever possible, staff on night duty or rostered days off were contacted and asked to participate. Major hospitals were also visited during night shifts.

Each survey respondent completed a self-administered questionnaire, assisted when required with English or specific terminology. Data were collected on age, sex, ethnic group, occupation, geographic location (rural, semi-rural or urban), duration of service, patient contact, handling of blood and used needles, and personal and household history of hepatitis infection.

Ten ml of venous blood were collected from each subject, clotted, centrifuged and frozen, and the serum flown on dry ice to Melbourne, Australia at the end of the survey. Sera were tested for HBV surface antigen (HBsAg), and antibody (anti-HBs) markers of HBV infection by radio-immunoassay using commercial assays (Abbott Laboratories, North Chicago I, II). A microtiter, solid phase radio-immunoassay was used to detect delta antigen and antibody (Dimitrakakis *et al,* 1984).

Prevalence rates of markers of HBV infection were estimated across age, ethnic and occupational groups. Multiple logistic regression analyses were performed to test for associations between the prevalence of markers of HBV infection and occupation, after adjusting for age, sex, ethnicity and geographic location. Analyses were restricted to Fijians and Indians less than 60 years of age for whom complete information was available (n = 2,400).

Logistic regression models were used to test for associations between HBV infection and self-reported contact with patients, blood and syringes (needles), adjusting for sex, ethnicity, and location. Because occupation is strongly associated with socio-economic status and contact with patients, blood and needles, attention was restricted to Fijian and Indian paramedic and auxiliary staff (n = 900), a socially relatively homogenous group of workers experiencing differential HBV exposure status. Only individuals aged less than 60 years for

Table 1

Fiji health care workers study population by sex and ethnic group.

Ethnic group	Survey respondents Male (n = 882) %	Survey respondents Female (n = 1,749) %	Survey respondents Both sexes (n = 2,639) %	Prism Report health workers listed (n = 2,637) %	Estimated % of Fijian population (1981*)
Fijian	35.4	62.7	53.5	56.0	44.7
Indian	56.8	30.0	39.0	37.5	50.2
Rotuman	1.8	1.8	1.8	6.5^+	1.2
Other Pacific Islanders	3.5	1.8	2.4		0.9
European	0.8	1.1	1.0		0.6
Part-European	0.6	1.2	1.0		1.7
Chinese	0.3	0.3	0.3		0.7
Filipino	0.5	0.2	0.3		0.1
Others not stated	0.3	0.9	0.7		

(gender not known for 8 subjects)

*From Carter J. Pacific Islands Year Book. 15th edition. Pacific Publications, Sydney, 1984.

$^+$ All ethnic groups excluding Fijians and Indians

whom complete data were available were included in the analysis.

All logistic models were fitted using the GLIM statistical package. The change in deviance for each variable entered into the model was used to assess statistical significance. Potential confounders (ie age, sex, ethnicity and location) were adjusted for. Duration of service was not included in the models because it is highly correlated with age (r = 0.72).

RESULTS

2,639 health workers (1,749 females, 882 males and 8 of unknown sex) were included in the survey (Table 1). Male and female subjects had similar age distributions (mean ages : males = 35.1 years; females = 34.5 years). The overall response rate for the survey was approximately 70%, ranging from 62.5% for medical staff to 104% for administrative and clerical staff (including non-established clerical workers) (Table 2). Response rates could not be calculated for occupational groups not mentioned in the Prism Report, such as non-permanent auxiliary staff. However, there was no reason to

Table 2

Response rates by occupation.

Occupational group	Number in study population	Response rate (%)
Medical	197	62.5
Dental	109	72.2
Nursing	904	63.3
Paramedical	236	72.2
Administrative and clerical	210	104.0
Sub total	1,656	68.3
Auxiliary	734	-
Students	242	-
Total	2,632	-

(occupation not known for 7 subjects)

Table 3

Prevalence of markers of HBV by ethnic group.

Ethnic group	Number tested	+ve HBsAg (%)	−ve HBsAg +ve anti-HBs (%)	Total prevalence (%)	Ratio +ve Ag : +ve Ag or Ab
Fijian	1,413	8.1	27.0	35.0	0.23
Indian	1,028	0.4	7.5	7.9	0.05
Other Pacific Islanders	111	13.5	30.6	44.1	0.31
European	26	-	7.7	7.7	
Others	42	-	7.1	7.1	-
Total	2,620	5.1	19.0	24.0	0.21

(ethnicity not known for 19 subjects)
Both sexes

suspect lower response rates in these groups.

The study population included similar proportions of Fijian, Indian and other ethnic group health care workers to those stated in the Prism Report (Fiji Ministry of Health, The Prism Report, 1984). However, there were more Fijians and fewer Indians in the survey population than in the general Fijian population (Table 1).

The total prevalence of HBV markers was 24% (641 subjects). 135 subjects (5%) tested positive for surface antigen (HBsAg) and 510 subjects (19%) expressed anti-HBV antibody (anti-HBs).

Rates of infection for specific ethnic groups are shown in Table 3. Prevalence rates of HBsAg are high for Fijian males and females (13% and 7% respectively), and for "other" Pacific Islanders (14%). Antigen carriage rate was much lower in Indians of both sexes (0.4%). The small number of European and "others" in the survey (n = 68); made comparisons difficult, however, none of these subjects were HBsAg positive and only 5 (7%) had anti-HBs. Sex and ethnic group variation of total HBV markers also occurred with rates of 47% and 32% for Fijian males and females, and 11% and 5% for Indian males and females respectively. "Other" Pacific Islanders also had a high rate for total HBV markers (44%), whilst European and "others" had lower rates (8% and 7% respectively).

Male Fijian and "other" Pacific Islanders had significantly greater HBsAg prevalences than females, and total HBV markers were also higher in Fijian and Indian males than females. The ratio of HBsAg to total HBV markers (Table 4) was higher for Fijians (0.23) and "other" Pacific Islanders (0.31) than for Indians (0.05).

Age-specific prevalence rates of HBsAg and anti-HBs are given in Table 4. Prevalence of anti-HBs rose significantly with age in both male and female subjects ($p < 0.05$), whereas HBsAg prevalence did not rise (Fig 1). However, ethnic specific, age-related trends in rates of HBsAg were only significant for Fijians ($p < 0.001$).

HBV marker prevalence varied with occupational group (Table 5). Auxiliary workers involved in patient care exhibited the highest prevalence of total HBV markers (31%) and HBsAg (8%). Paramedical staff without patient contact had the lowest rate of total HBV markers (13%), and administrative/clerical staff had the lowest rate of HBsAg (4%).

Amongst Fijians, the highest prevalence rates of total HBV markers were seen in paramedical staff with patient contact, administrative/clerical staff, and dental health workers (52%, 51% and 50% respectively). Students and nursing staff had the lowest prevalence rates of total HBV markers (27% and 29%). The highest prevalence rates of

Table 4

Age-specific prevalence of markers of HBV infection.

Age group (years)	N	+ve HBsAg (%)	−ve HBsAg +ve anti-HBs (%)	Total prevalence (%)	Ratio +ve Ag : +ve Ag or Ab
15-19	72	6.9	9.7	16.7	0.41
20-24	525	4.4	14.9	19.3	0.23
25-29	457	4.4	12.5	16.9	0.26
30-34	360	5.6	16.7	22.3	0.25
35-39	286	4.2	17.1	21.3	0.20
40-44	341	6.2	24.9	31.1	0.20
45-49	281	5.7	26.3	32.0	0.18
50-54	207	7.2	29.0	36.2	0.20
55-59	94	2.1	35.1	37.2	0.06
≥ 60	11	9.1	-	9.1	1.00
All ages	2,634	5.1	19.0	24.0	0.21
x^2 for trend		ns	$p < 0.001$	$p < 0.001$	

(age not known for 5 subjects)
Both sexes, all ethnicities.

Table 5

Prevalence of markers of HBV infection by occupational group.

Occupation	Number tested	+ve HBsAg (%)	−ve HBsAg +ve anti-HBs (%)	Total prevalence (%)	Ratio +ve Ag : +ve Ag or Ab
Medical	197	4.1	12.2	16.2	0.25
Dental	109	7.3	16.5	23.8	0.31
Nursing	904	4.3	19.8	24.1	0.18
Paramedical (patient care)	117	4.3	18.8	23.1	0.19
Paramedical (no patient care)	119	5.0	8.4	13.4	0.37
Auxiliary (patient care)	121	8.3	23.1	31.4	0.26
Auxiliary (no patient care)	613	5.9	22.4	28.2	0.21
Administration and clerical	210	3.8	24.3	28.1	0.14
Students	242	6.2	14.1	20.2	0.31
Total	2,632	5.1	19.0	24.0	0.21

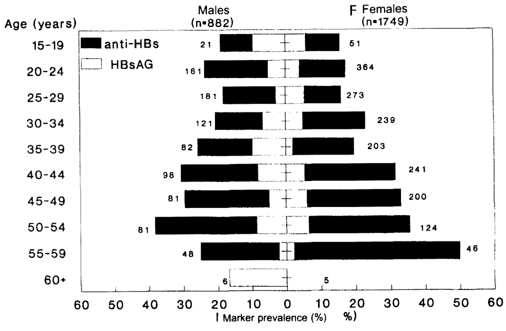

Fig 1—Fiji health care workers HBV marker prevalence by sex and age group.

HBsAg were observed in paramedical staff (with and without patient contact) and dental health workers (17%, 13% and 22% respectively), whilst nurses had the lowest rate (6%).

Indians experienced much lower prevalence of HBV markers, with the highest rates of total markers (approximately 15%) being observed for paramedical and auxiliary staff, both involved in patient care. Only four Indian subjects were possitive for HBsAg.

Table 6

Odds of hepatitis B infection by occupation in health care workers adjusted for age, sex, ethnic group and location.

Occupational group	Odds of infection	95% Confidence interval
Paramedics (no patient contact)	1.00*	-
Medical	1.65	(0.77, 3.53)
Dental	3.10	(1.38, 6.94)
Nursing	1.40	(0.72, 2.71)
Paramedics (patient contact)	3.23	(1.45, 7.22)
Auxiliaries (patient contact)	2.01	(0.94, 4.26)
Auxiliaries (no patient contact)	1.46	(0.76, 2.78)
Administrative	2.25	(1.11, 4.58)
Students	1.38	(0.65, 2.94)

*Reference group
Aged < 60 years, n = 2,400
Change in deviance after fitting occupation = 21.2, 8df (p < 0.01).

Table 7

Paramedic and auxiliary staff : occupational categories and patient contact classification.

Staff type	Patient contact	No patient contact
Paramedics	Physiotherapist Laboratory technician Radiographer	Dietitian Pharmacist Health Inspector Research scientist Health educator Dental technician
Auxiliaries	Nurse aide Orderly/attendant Dresser Village health worker X-ray assistant	Cleaner/maid Cook/kitchenhand Seamstress/laundryhand Storeman/packer Pharmacy assistant Maintenance assistant Laboratory attendant Driver/laborer/gardener Medical engineer CSSD attendant

Table 8

Odds of hepatitis B infection for blood and needle contact in Fiji paramedical and auxiliary health workers (each model adjusted for age, sex, ethnic group and location).

Exposure		Odds of infection	95% Confidence interval	Change in deviance	Degrees of freedom	p
Blood :	No	1.00	-			
	Yes	1.57	(1.04, 2.38)	4.4	1	< 0.05
Needles :	No	1.00	-			
	Yes	1.63	(1.09, 2.44)	5.5	1	< 0.05
Blood and/or needles :	No	1.00	-			
	Yes	1.77	(1.20, 2.60)	8.4	1	< 0.01
Patient contact :						
	Daily	1.00	-			
	< Daily	0.90	(0.49, 1.63)	3.1	2	ns
	Never	0.71	(0.48, 1.04)			

n = 900 cases
Fijians and Indians aged < 60 years only.

For Fijian and Indian health staff under 60 years of age (data available for 2,400 subjects), logistic regression modelling showed an apparent effect of occupational group ($p < 0.01$) after controlling for age, sex, ethnic group and location. The odds of infection were calculated for specific occupational subgroups, relative to the odds for paramedics with no patient contact (the group with the lowest prevalence rate) (Table 6). The odds of infection for dental, paramedics (with patient contact) and administrative staff were significantly higher than for the reference group.

Analysis of the data for apparent influence of hepatitis B exposure (patient, blood and needle contact) on HBV marker status was restricted to auxiliary and paramedic staff (Table 7). A significant effect of exposure to blood and/or needles was found after adjusting for age, sex, ethnicity and location (odds ratio = 1.8, $p < 0.01$). Separate analyses showed significant associations between HBV prevalence and exposure to blood (odds ratio = 1.6, $p < 0.05$) and exposure to needles (odds ratio = 1.6, $p < 0.05$) after adjusting for potential confounders (Table 8). However, of the 235 individuals exposed to blood and/or needles, 65% were exposed to both, hence there is limited information on the independent effects of these exposures.

A comparison of these survey results with data from a 1980 population-based cluster sample of the general population indicated that the HBsAg rate was lower in both Fijian and Indian health care workers than the general population (Zhuang *et al*, 1982). For Fijians, the age-adjusted* HBsAg prevalence in health care workers was only slightly lower than in the general population (8.9% versus 11.5%). In Indians the rate was much less for health care workers (0.3% versus 2.0%). However for urban Indian subjects only, HBsAg carriage rates were similar in health workers (0.3%) and the general population (0.5%).

DISCUSSION

Immunization of health care workers against HBV is now common policy in western developed countries. Health staff constitute a particular at-risk group, being more exposed to hepatitis B patients and infected blood than the general population. In less developed countries the background

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* Standardized to population structure of Fiji in mid-1982 using the direct method.

prevalence of HBV in the community is often much higher. Spread of infection is probably by perinatal means and by direct contact during childhood.

The decision to immunize health workers depends on the relative levels of infection in health staff and the general public, and whether there is evidence of occupational transmission. Mass vaccination will not have much impact within the health service if staff have already gained high rates of immunity through infection during childhood. This survey attempted to identify the prevalence of hepatitis B infection in the Fiji Ministry of Health workforce, and to compare these with the general population of Fiji. A further aim was to see if particular at-risk groups of health workers had a higher risk of infection.

The study was difficult to perform, and not all the objectives could be achieved. A variable but low response rate (70%) may have affected the accuracy of the results. Medical and nursing staff recorded the lowest response rates. This could be due to irregular working hours for these groups, work pressure during the survey, or a disinclination to have their hepatitis antigen status determined because of possible occupational consequences. The highest response rates were obtained for groups who worked mainly normal working hours such as dental, paramedical and administrative staff.

The ethnic differential in prevalence of hepatitis B in Fiji has been noted in the past, and may be associated with differential exposure to the virus during childhood (Gust *et al,* 1979; Zhuang *et al,* 1982). Fijians and Indians exhibit cultural, behavioral and lifestyle differences that influence transmission. Fijian communities often operate as open villages, affording more opportunity for close contact than the extended family arrangements within Indian groups. Furthermore, the rate at which those infected with hepatitis B become chronic carriers appears to be age-dependent - ie the younger a person becomes infected, the greater the long-term carriage rate. The prevalence ratio of HBsAg to total HBV markers in a population reflects the average age of acquisition of infection. Higher ratios of antigen to total hepatitis markers found amongst Fijians and "other" Pacific Islanders suggest earlier age of infection in these groups compared to Indians.

Sex differences in HBV infection have also been noted previously with higher prevalence rates of HBsAg amongst males (Austing *et al,* 1974; Gust *et al,* 1979; Zhuang *et al,* 1982). The reasons for this are unclear, although boys may sustain minor trauma more frequently than girls, thus providing portals of exit and entry for the virus.

In contrast to Zhuang *et al's* findings, this survey found a lower prevalence of hepatitis surface antibody in Fijians from rural areas (17%) compared with urban areas (35%) (Zhuang *et al,* 1982). There was no obvious explanation for this finding.

Certain occupational categories were identified with higher rates of hepatitis B infection. However, HBV infection could not be definitely linked to exposure on a group basis since there was no consistent pattern. Both dentists and administrative staff had elevated odds of hepatitis B compared to the reference group.

Problems exist in the ascertainment of risk specifically due to exposure. Several known risk factors for HBV infection such as age, sex, ethnic group and socio-economic status all act as confounders for occupation related risk of infection. These demographic variables are also associated with occupation and other behavioral and cultural characteristics that influence transmission. Furthermore, it is reasonable to assume relative homogeneity of exposure status within some subgroups of health workers such as doctors, nurses and dentists. Most medical staff will at some stage have had significant contact with HBV infected patients, blood or blood products, and thus cannot be examined to study the effect of differential exposure on risk of HBV infection.

For these reasons it was not possible to determine a general association between health, occupation, exposure and HBV infection. To minimize the effects of confounders, and of uniform HBV exposure in some subgroups, Fijian and Indian paramedic and auxiliary health workers were selected for further analysis. Using a logistic model to control for age, sex, ethnic group and location, significant associations between exposure to blood and/or needles and total prevalence of markers of HBV infection were observed in these groups. No significant association was observed for patient contact. These findings are consistent with results presented in a recent review of HBV infection in health care workers (Hadler, 1990). Further analyses were not conducted in other occupational subgroups, or for other markers of HBV infection, because of the limitations of the data.

Universal precautions and hepatitis B vaccine have been identified as the two most effective methods of minimising occupational HBV infection (Hadler, 1990). The results of this study indicate that there is some evidence of occupational transmission of HBV in Fiji health care workers. However, vaccination of these workers in preference to neonatal vaccination does not seem to be justified given that this group has a lower rate of HBV infection than the general population. Improved procedures for the handling of blood products and used syringes by health care workers appears to be the most appropriate strategy for reducing the risk of infection in the workplace.

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REFERENCES

Austin FAJ, Maguire T, Miles JR. The occurrence of hepatitis B antigen and antibody in some population groups in the southwest Pacific region. *Am J Trop Med Hyg* 1974; 23 : 489-94.

Blumberg BS, Gerstley BJS, Hungerford DA, *et al.* A serum antigen (Australia antigen) in Down's syndrome, leukemia and hepatitis. *Ann Intern Med* 1967; 66 : 924-31.

Denes AE, Smith JL, Maynard JE, *et al.* Hepatitis B infection in physicians : Results of a nationwide seroepidemiologic survey. *JAMA* 1978; 239 : 210-2.

Dimitrakakis M, Coulepis AG, Pringle RC, Gust ID. Detection of delta infection using reagents obtained from the serum of patients infected with HBV. *J Virol Methods* 1984; 8 : 331-4.

Fiji Ministry of Health. The Prism Report. Internal report of Fiji Department of Health staffing levels. Ministry of Health, Suva, Fiji, 1984.

Gust ID, Dimitrakakis M, Zimmet P. Studies of hepatitis B surface antigen and antibody in Nauru : I. Distribution amongst Nauruans. *Am J Trop Med Hyg* 1978; 27 : 1030-36.

Gust ID, Lehmann NI, Dimitrakakis M. A seroepidemiologic study of infection with HAV and HBV in five Pacific Islands. *Am J Epidemiol* 1979; 110 : 237-42.

Hadler SC. Hepatitis B virus infection and health care workers. *Vaccine* 1990; 8 (Suppl) : S24-S8.

Hawkes RA, Boughton CR, Ferguson V, Vale TG. The seroepidemiology of hepatitis in Papua New Guinea. II. A long-term study of hepatitis B. *Am J Epidemiol* 1981; 114 : 563-73.

Heathcote J, Cameron CH, Dane DS. Hepatitis-B antigen in saliva and semen. *Lancet* 1974; 71-5.

Khalfa S, Ardjoun H. Epidemiologie des hepatites virales en Algerie. *Med Trop* 1984; 44 : 247-52.

Leichtner AM, LeClair J, Goldmann DA, *et al.* Horizontal non-parenteral spread of hepatitis B among children. *Ann Intern Med* 1981; 94 : 346-9.

Lewis TL, Alter HJ, Chalmers TC, *et al.* A comparison of the frequency of hepatitis-B antigen and antibody in hospital and non-hospital personnel. *N Engl J Med* 1973; 289 : 647-51.

Maynard JE. Viral hepatitis as an occupational hazard in the health care profession. In : Vyas GN, Cohen SN, Schmid R, eds. Viral hepatitis : A contemporary assessment of aetiology, epidemiology, pathogenesis and prevention. Philadelphia : Franklin Institute Press, 1978.

Mazzur S, Bastiaans MJS, Nath N. Heptitis B virus (HBV) infection among children and adults in the Solomon Islands. *Am J Epidemiol* 1981; 113 : 510-9.

Pattison CP, Maynard JE, Berquist KR, Webster HM. Epidemiology of hepatitis B in hospital personnel. *Am J Epidemiol* 1975; 101 : 59-64.

Snydman DR, Munoz A, Werner BG, *et al.*A multivariate analysis of risk factors for hepatitis B virus infection among hospital employees screened for vaccination. *Am J Epidemiol* 1984; 120 : 684-93.

South Pacific Commission Report of regional workshop on hepatitis. South Pacific Commission, Noumea, New Caledonia, 1981.

Taylor R, Montaville B Levy S, *et al.* Hepatitis B infection in Vanuatu : age of acquisition of infection and possible routes of transmission. *Asia Pacif J Public Health* 1989; 3 : 205-12.

Taylor R, Whitmore J, Gust I, *et al.* Seroepidemiological studies of hepatitis B in Niue, 1980-83. South Pacific Commission Technical Paper No. 182, Noumea, New Caledonia, 1984.

Tibbs CJ. Hepatitis B, tropical ulcers, and immunization strategy in Kiribati. *Br Med J* 1987; 294 : 537-40.

Villarejos VM, Visona PHKA, Gutierrez A, Rodriguez A. Role of saliva, urine and faeces in the transmission of type B hepatitis. *N Engl J Med* 1974; 291 : 1375-8.

Wainwright RB, McMahon BJ, Bender TR, *et al.* Prevalence of hepatitis B virus infection in Tonga : Identifying high-risk groups for immunisation with hepatitis B vaccine. *Int J Epidemiol* 1986; 15 : 567-71.

Williamson HG, Gust ID, Dimitrakakis M, *et al.* Serological markers of hepatitis B infection in Niue children. *NZ Med J* 1985; 98 : 275-7.

Wong DC, Purcell RH, Rosen L. Prevalence of antibody to hepatitis A and hepatitis B viruses in selected populations of the South Pacific. *Am J Epidemiol* 1979; 110 : 227-36.

Zhuang H, Coulepis AG, Gust ID, *et al.* A cross sectional study of markers of hepatitis B infection in Niue. *NZ Med J* 1983; 96 : 330-2.

Zhuang H, Coulepis AG, Zimmet P, *et al.* Seroepidemiology of infection with hepatitis B virus in Fiji. *Am J Epidemiol* 1982; 116 : 608-16.