The term “expatriates” refers to professionals and their families who live abroad for several months or years. Owing to potential prolonged exposure, and living conditions that may be closer to those of the local population, they are at higher risk of acquiring infectious diseases that are endemic in their new place of residence. They often have reduced access to medical services, putting them at higher risk of complications and more severe outcomes. Vaccination is probably one of the most effective means of preventing expatriates from acquiring endemic or epidemic diseases. Incapacitation or sickness in the field may cause serious disruption to project activities and impose an extra workload on the local team. It may also result in repatriation, with further extra direct and indirect costs for the organization. Predeparture advice and preparation, to promote risk reduction behavior, coupled with adequate support in the field are key ingredients to ensure effective and successful activities of collaborators. Institutions and organizations sending expatriates to developing countries have a clear responsibility, and it is in their own interests to promote the health of their employees working abroad.

Commonly reported health problems in Peace Corps Volunteers and refugee relief workers are diarrhea, respiratory illnesses, injuries, and skin conditions. Mortality studies in missionaries and in Peace Corps volunteers showed that motor vehicle accidents ranked highest among the risks. Among humanitarian workers, death was mainly caused by intentional violence, and motor vehicle accidents ranked second. Occupation and nationality expose expatriates to harm and risk of death from intentional violence. On average, 5% to 7% of expatriates are unable to complete their assignment for medical and psychological reasons.

In this review, we do not discuss the health of the local staff or regional expatriates with whom expatriates from industrialized countries work. They may be at even higher risk of suffering from infectious diseases and violent death, and important ethical issues have to be considered with regard to access to preventive measures and medical care.

Prevention

The promotion of the health of expatriates is the responsibility of the sending organization. It is for the ben-
immunizations and have received appropriate booster doses. These provide protection against diseases prevalent in many parts of the developing world. Tetanus and diphtheria are found worldwide. Recently, diphtheria epidemics have occurred in the former Soviet Union. Poliomyelitis transmission still occurs in sub-Saharan Africa and South Asia. Vaccination or documented immunity to measles is highly recommended for expatriate individuals. Expatriates originating from tropical countries, where varicella is less prevalent, may be at risk of acquiring varicella if posted to the northern hemisphere. Vaccination should be considered.

Currently, only two vaccines, those for yellow fever and meningitis, may be required officially in certain countries. Yellow fever vaccination is mandatory for entry into most sub-Saharan countries, Panama, and French Guiana, but yellow fever is also endemic in most countries of the Amazonian basin. Pilgrims entering Saudi Arabia for the Hajj pilgrimage need proof of vaccination against meningococcal meningitis with a quadrivalent vaccine. In the past, certain countries required a certificate of vaccination against cholera. Table 4 summarizes data on incidence rates in expatriates for vaccine-preventable diseases in the developing world. There are very few stud-

### Table 1  Difficulties and Hardship Experienced by Long-term Expatriates

<table>
<thead>
<tr>
<th>Difficulty</th>
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<tbody>
<tr>
<td>Isolation and loneliness</td>
</tr>
<tr>
<td>Cross-cultural adjustment and communication difficulties</td>
</tr>
<tr>
<td>Difficult living conditions and harsh environment</td>
</tr>
<tr>
<td>Unreliable means of communication and transportation</td>
</tr>
<tr>
<td>Relatively low professional and psychological support</td>
</tr>
<tr>
<td>Lack of community and family network and support (away from relatives and friends)</td>
</tr>
<tr>
<td>Exposure to poverty and suffering</td>
</tr>
<tr>
<td>Exposure to violence, insecurity and death</td>
</tr>
<tr>
<td>Exposure to infectious diseases</td>
</tr>
<tr>
<td>Always immersed in professional activities</td>
</tr>
<tr>
<td>Higher level of responsibility and self-sufficiency</td>
</tr>
<tr>
<td>Lack of privacy</td>
</tr>
<tr>
<td>Little opportunity to rest and socialize</td>
</tr>
<tr>
<td>Reduced access to medical services</td>
</tr>
</tbody>
</table>

### Table 2  Promoting the Health of Expatriates

<table>
<thead>
<tr>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have a clear policy to promote the health of expatriates</td>
</tr>
<tr>
<td>Inform on risks and how to reduce them</td>
</tr>
<tr>
<td>Promote easy access to information</td>
</tr>
<tr>
<td>Give clear, simple and effective guidelines</td>
</tr>
<tr>
<td>Have predeparture medical evaluation, vaccination, and counseling</td>
</tr>
<tr>
<td>Promote easy access to preventive measures: malaria prophylaxis, condoms, seat belts, helmets</td>
</tr>
<tr>
<td>Have access to medicines and a medical kit for common illnesses</td>
</tr>
<tr>
<td>Have access to medical services, to referral, and medical advice</td>
</tr>
<tr>
<td>Have adequate insurance protection, including for medical evacuation</td>
</tr>
<tr>
<td>Enforce preventive measures: reminders</td>
</tr>
<tr>
<td>Epidemiologic surveillance: regular data collection</td>
</tr>
</tbody>
</table>

### Table 3  Vaccinations for Expatriates to be Considered According to Destination

<table>
<thead>
<tr>
<th>Vaccination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine vaccinations (according to age):</td>
</tr>
<tr>
<td>Diphtheria, tetanus, poliomyelitis, pertussis, <em>Haemophilus influenzae</em> type b, measles, mumps, rubella, varicella, hepatitis B, influenza, pneumococcal infection</td>
</tr>
<tr>
<td>Required/mandatory</td>
</tr>
<tr>
<td>Yellow fever, meningococcal meningitis (Hajj pilgrimage)</td>
</tr>
<tr>
<td>Recommended:</td>
</tr>
<tr>
<td>Hepatitis A, hepatitis B, typhoid fever, rabies, meningococcal meningitis A/C/Y/W135, Japanese encephalitis, tick-borne encephalitis, cholera, BCG</td>
</tr>
</tbody>
</table>

*For children.

*For at-risk groups.
ies, often conducted on specific groups with small population sizes. They may illustrate the local conditions and specificities, and one should be careful not to over-generalize these results. As expected, they show incidence rates that are much higher than those of normal travelers, due to longer duration of exposure, higher risk activities, and living conditions often close to those of the local population.

**Officially Required Vaccinations**

**Yellow Fever**

Yellow fever is a potentially lethal mosquito-borne viral hemorrhagic fever, and is endemic in parts of sub-Saharan Africa and South America. The mortality rate is 20% to 50%. No specific antiviral drug is currently available, making vaccination even more important. In rural West Africa, during interepidemic periods, the incidence of yellow fever is 1.1 to 2.4 cases/1,000 persons, and the incidence of death is 0.2 to 0.5/1,000 persons. In Africa, the risks of illness and of death due to yellow fever in unvaccinated travelers are estimated to be 1/1,000 and 1/5,000 per month respectively. The risk is 10 times lower in South America. During epidemic activity, the risk of contracting yellow fever for an unimmunized person was estimated to be 1/267 (death: 1/1,333) for a 2-week visit; this translates to 750 and 150, respectively, per 100,000 per month. The disease has been uncommon in travelers, due to high immunization rates. Only 11 cases were reported by 1999 in unvaccinated individuals after the yellow fever 17D vaccine became available in 1950.

One dose of this vaccine, a live attenuated strain of the 17D yellow fever virus, is extremely effective (~99%) and provides long-term protection (>10 years). A booster dose is required every 10 years. Adverse events resulting from vaccination have recently drawn attention: since 1996, nine cases of yellow fever vaccine-associated viscerotropic disease (YEL-AVD), a disease clinically and pathologically resembling naturally acquired yellow fever, have been reported in the United States; an additional 14 cases had been identified worldwide as of July 2004. Fourteen (61%) of these cases were fatal. In the United States, the reported incidence is about 3 cases per million civilian doses distributed. Individuals older than 60 years seem to be at increased risk. Four (17%) of the 23 vaccinees reported as having this syndrome had a history of thymus disease, suggesting that thymic dysfunction is an independent risk factor for YEL-AVD. The vaccination is required for all expatriates based in a country of endemicity or crossing international borders from a country of endemicity to a country free of yellow fever where the vector is present. Family members should be vaccinated as well.

**Meningococcal Meningitis**

The quadrivalent meningococcal meningitis vaccine is officially required for pilgrims entering Saudi Arabia for the Hajj pilgrimage. For a detailed description of the vaccine, see “Recommended Vaccinations”.

**Recommended Vaccinations**

**Hepatitis A**

Hepatitis A is easily contracted in many parts of the world through contaminated food or water. The monthly incidence rate is 300 to 600/100,000 in a developing country in nonimmune travelers. The risk can be even higher for expatriates. Of 108 French volunteers working in rural Central and West Africa in 1979–1980 without any immunity against hepatitis A, 19 per 1,000 per month seroconverted. US missionaries serving in sub-Saharan Africa between 1967 and 1984 experienced attack rates as high as 28% during the first 2 years of service. Assuming a linear rate of infection, the
monthly incidence rate is 1,700/100,000. In a cross-sectional serosurvey (1986) of 380 missionaries and their dependants posted to Papua New Guinea who had not received gamma-globulin, 47% were anti-hepatitis A virus (HAV) positive for IgG antibodies. The mean duration of stay in the country was 100 months.16 Hepatitis A occurred frequently in the military.17 During the Korean conflict in 1950, 4,000 patients with hepatitis were hospitalized despite the use of immunoglobulin, and many cases of hepatitis occurred during the war in Vietnam. In 1978, unprotected French soldiers in Lebanon suffered an epidemic (154 cases/1,000 men/year). From 1957 to 1962, 0.9% of Norwegian troops developed hepatitis A in Gaza.18

In most instances, hepatitis A in adults is a self-limiting disease. Nevertheless, it can cause prolonged incapacity to work, with long-lasting fatigue and an increasing frequency of severe cases and mortality over the age of 45 years. In difficult climatic and environmental conditions, hepatitis A can be debilitating and require repatriation. There are four equally very effective (99%) inactivated HAV vaccines available, with two doses administered 6 to 12 months apart. The vaccine provides long-term immunity; with anti-HAV antibodies persisting for up to 12 years. Mathematical models predict that antibody levels will persist beyond 25 years.19 As small children are seldom symptomatic, it may spread unnoticed within the household and contaminate other members of the family. Children should also be immunized. Since the introduction of the very effective hepatitis A vaccines, immunoglobulin is being used less and less, because of its limited duration of protection. It can be used in expatriates who are leaving less than 2 weeks after receipt of hepatitis vaccine, those who are unable to receive the hepatitis A vaccine, and compromised hosts, who are likely to respond poorly to immunization. Following exposure to HAV, when administered within 2 weeks, immunoglobulin is >85% effective in preventing hepatitis A infection.

Hepatitis B

Hepatitis B virus (HBV) is highly endemic in Africa, in the Asia Pacific region and in most other parts of the developing world. Contact with infected blood or other body fluids, and unprotected sex, are risk factors for infection.

Although several studies have addressed the risk of hepatitis B in expatriates, most of these had very small sample sizes and variable durations of follow-up. Expatriates living in countries of high endemicity have a significant risk of acquiring hepatitis B. Of 219 French volunteers in rural sub-Saharan Africa, 23 (10.5%) developed HBV infection during an 18- to 35-month period, a rate of 5 per 1,000 per month.15 Sixty-one percent had no jaundice reported. Assuming a linear rate of infection, Steffen estimated a monthly incidence of 0.8 to 4.2/1,000 in expatriates.20 US missionaries in Africa had an infection rate of 11% during the first 1 to 2 years; the median annual attack rate was 4.2% for HBV.15 Of missionaries and their dependants in Papua New Guinea, 9.5% had acquired HBV infection; 31% were <16 years old.16 Recently, a prospective study conducted in 124 unvaccinated Dutch missionaries and their family members living in rural Nigeria found a seroconversion rate of 1.7/1,000 personmonths at risk in adults and 2.8/1,000 personmonths at risk in children.21 More than 50% of the infections were subclinical. The presence of a Nigerian child living in the family and having attended a local school were the two significant risk factors identified. None had undergone major surgery or had received blood transfusions. No questions on sexual behavior were asked. Studies have shown high-risk sexual behavior, with up to 50% of European expatriates living in sub-Saharan Africa reporting casual and unprotected sex with local partners.22–24

The risk of expatriates and their dependants of acquiring HBV is 1% to 5% per year. All should be vaccinated against hepatitis B. This includes children, who are at higher risk of infection and much more prone to develop chronic disease. The implementation of an HBV vaccination strategy for expatriates may not be easy. A study showed that advising Dutch expatriates to be vaccinated increased the percentage of vaccinated subjects from 14% to 37%; however, this was not sufficient to decrease significantly the HBV infection rate (from 6.7% to 5.4%) in this population.24 Young females with low-risk behavior were more protected (65%) than were older male expatriates with high-risk behavior (20%). HBV control strategy in expatriates consists of enforcing systematic vaccination, education campaigns on condom use, and avoiding high-risk behavior. Medical professionals are at higher risk of infection.

The vaccines available have been proven to be safe and effective, offering protection for over 10 years, perhaps lifelong for symptomatic infection.25 Hepatitis B vaccination is given at 0, 1 and 6 months. Seroconversion rates after three doses vary from 80% to 100% in healthy adults.

Nonresponders (with antibody levels <10 IU/L) can be offered three additional doses of vaccine. A combined three-dose vaccine for both hepatitis A and hepatitis B is available, and should be given at months 0, 1, and 6. The vaccine is especially suitable for long-term expatriates.

Typhoid Fever

In developing countries, the incidence of typhoid fever may be 540 cases per 100,000 population per year,26 and 500,000 typhoid fever patients will die of the infec-
tion. The majority of imported cases in Europe and in North America are acquired in South and Southeast Asia.27 Attack rates for typhoid fever in travelers are 3 per 100,000 per month, and are 10 times higher when travelers are returning from India.28 Multiresistant strains of Salmonella typhi are increasingly common worldwide, and in the Indian subcontinent in particular. Thirty percent of isolates from imported cases in the United States in 1994 were resistant to ampicillin, chloramphenicol, and trimethoprim–sulfamethoxazole.27 In 1996–1998, during an epidemic of typhoid fever in Tajikistan, up to 82% of Salmonella strains were resistant to fluoroquinolones.29 To date, there are no data on the frequency of typhoid fever in expatriates.

There are currently two vaccines used against typhoid fever: the purified Vi polysaccharide parenteral vaccine, and the Ty21a live oral vaccine. Both vaccines were initially evaluated in populations living in endemic regions. The efficacies of the Ty21a vaccine were 74% for the liquid formula and 47% for the enteric capsules, and the Vi vaccine had 55% to 72% protective efficacy.29,30 A meta-analysis established that two doses of the old whole-cell vaccine provided 73% efficacy vs. 51% and 55% respectively for the Ty21a and Vi vaccines.31 However, fever occurred in 15.7% of whole-cell vaccine recipients vs. 2% and 1.1%, respectively, for the other vaccines. A study in Chile showed a higher level of efficacy when four doses of vaccine were used; this is the regimen for Ty21a in the United States and Canada.32

The protective efficacy in travelers and expatriates has not been evaluated. Of 1,305 patients with travel-associated typhoid fever, 3% had been vaccinated in the 2 years before illness.27 For expatriates and their dependants working in typhoid fever–endemic countries, vaccination is recommended.

**Meningococcal Meningitis**

Worldwide, the incidence of meningococcal meningitis probably exceeds 100,000 cases every year. The majority of these cases occur during epidemics in the meningitis belt in sub-Saharan Africa.33 In this region, incidences of 5 and 15 cases per 100,000 per week (20 and 60/100,000/month) are considered to be the alert and epidemic thresholds, respectively.34 During epidemics in Africa, the rate can reach 1,000 per 100,000 per year. The disease has significant morbidity and mortality, with a case fatality rate between 5% and 10%. Serogroup A has been the most common cause of epidemics in sub-Saharan Africa. In the year 2000, there was an epidemic linked to the Hajj pilgrimage to Mecca, in which the majority of cases were due to serogroup W135. Of an estimated 1.3 million pilgrims, 330 developed meningococcal infection in Europe, North America, and the Middle East (25/100,000), with over 70 deaths.35 This epidemic raised serious concern, as W135 had never caused an epidemic of this size, which then spread to West Africa in the following year. This led to discontinuation of the use of the bivalent (serogroups A and C) vaccine, and mandatory use of the quadrivalent (A, C, Y, W135) polysaccharide vaccine for all pilgrims to Mecca, and subsequent financial difficulties in the control of epidemics in sub-Saharan Africa, the vaccine being considerably more expensive and not available in sufficient amounts. The risk for travelers of acquiring meningococcal meningitis was estimated in a questionnaire survey directed to health authorities. The authors estimated that the risk among travelers to hyperendemic countries was 0.04 per 100,000 travelers per month.36 The rate for pilgrims traveling to Mecca was 200/100,000.

The risk of acquiring meningococcal meningitis increases during large gatherings, such as the Hajj or refugee camps. Many parts of Asia have also experienced epidemics of meningococcal disease.37 A large epidemic originated in Nepal in 1983, and later spread to India and Africa through the Hajj. In 1994, Mongolia experienced a large outbreak. Vaccination with the quadrivalent polysaccharide vaccine is indicated for all travelers in areas with active outbreaks. It is also recommended for expatriates in the meningitis belt and in regions that have experienced epidemics in the past 2 to 3 years. Other high-risk groups should be immunized, such as military personnel, hospital and health care staff, field epidemiologists, and aid workers.33,35 Travelers with immunodeficiencies should also be protected. This population is at risk for disease, but has a suboptimal response to vaccination.

The vaccine is safe, and its efficacy is greater than 80%, although it is not very immunogenic in children less than 2 years of age. Crossover vaccination of quadrivalent meningococcal vaccine in persons previously vaccinated with the bivalent vaccine is safe.37 Unvaccinated expatriates who have been in close contact with a case of meningococcal meningitis should receive postexposure chemoprophylaxis with ciprofloxacin (single dose of 500 mg in adults) or rifampicin (10 mg/kg every 12 h for 2 days in children > 1 month of age).33

**Rabies**

The World Health Organization (WHO) estimates that rabies causes over 50,000 human deaths annually worldwide.38,39 Dog bites are the primary cause of rabies transmission. Encephalitis due to rabies is untreatable.40 The disease can only be prevented by vaccination. Swiss and German experts and their family members living in tropical countries had an estimated risk of 18.2 bites per 1,000 persons per year, which corresponds with findings among missionaries from Norway.41,42 Of 58 subjects bitten, 16 (27.6%) were children. Dogs were involved in 69%
of incidents; 78% were either pet animals from the household or the owner was known. Peace Corps volunteers working for 2 years in 31 rabies-endemic countries had a postexposure treatment rate of 43.6 per 1,000 per year. In Nepal, the incidences of tourists and resident expatriates with possible rabies exposure were respectively 1.9 and 5.7 per 1,000 persons per year (16 to 48/100,000/month). In Thailand, 1% of travelers are bitten by dogs.

There are three types of tissue culture rabies vaccine available for use and recommended by the WHO: human diploid cell vaccine, Vero cell vaccine, and purified chick embryo cell vaccine. They are equally effective. Preexposure vaccination consists of three intramuscular injections on days 0, 7, and 21 or 28. A fourth injection may be administered, with a higher risk of allergic reaction. Postexposure vaccination for those with no prior preexposure vaccination consists of five intramuscular injections at days 0, 3, 7, 14, and 28. RIG is administered simultaneously with the first vaccine dose, being infiltrated locally at the bite site. In some areas, such as Thailand, effective vaccination schedules using the intradermal route have been developed.

In many parts of the developing world, the modern tissue culture rabies vaccines are not available or are only available in large urban centers. Only nerve tissue-derived rabies vaccines of unreliable potency and with high rates of associated complications are still being used. Preexposure prophylaxis for those who have received a full primary course is given as soon as possible after a bite as only two injections with a tissue culture rabies vaccine at an interval of 3 days, no rabies immunoglobulin (RIG) being necessary. Postexposure vaccination for those with no prior preexposure vaccination consists of five intramuscular injections at days 0, 3, 7, 14, and 28. RIG is administered simultaneously with the first vaccine dose, being infiltrated locally at the bite site. In some areas, such as Thailand, effective vaccination schedules using the intradermal route have been developed.

Thorough washing of rabies-infected wounds with soap and water should always be done.

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Japanese Encephalitis
JE is a mosquito-borne arboviral disease endemic in the rural areas of Nepal, India, and Southeast Asia, and also in parts of Japan, Taiwan, China, and Korea. It is transmitted seasonally in most areas by Culex mosquitoes, which bite primarily at night in rural areas. This flavivirus may cause a severe encephalitic disease. The associated mortality rate is 30% to 40%, and up to 50% of those who survive may have neurologic sequelae.

Tick-borne Encephalitis
Tick-borne encephalitis (TBE) or Fürth–Sommer meningoencephalitis is endemic in central and eastern Europe and in Russia. The TBE virus is a flavivirus transmitted by Ixodes tick bites. There are two subtypes, the eastern and the western subtypes. When endemic, TBE is a significant cause of morbidity and mortality, and its incidence has steadily increased in the last 10 years. The highest attack rates may reach 115 to 199 reported cases...
per 100,000 inhabitants per year in Latvia, the Urals, and the western Siberian regions of Russia. A study among soldiers in central Europe estimated the risk of acquiring symptomatic TBE as 1/38,000 personmonths of exposure.\textsuperscript{55} Expatriates are at risk through professional or recreational activities, such as fishing, hunting, or hiking. Currently, in Europe there are two inactivated purified whole-virus vaccines for those at high risk. Based on the important reduction in the incidence of TBE cases following mass vaccination in Austria,\textsuperscript{66} a vaccine efficacy of over 95\% has been reported.\textsuperscript{53} Recently, a Cochrane review of TBE vaccines concluded that the vaccines were highly immunogenic, but that the relationship between seroconversion and clinical protection had not been established.\textsuperscript{57} A primary course consists of three doses at 0, 1 and 9 to 12 months, or four doses at days 0, 7 and 21 and after 1 year. A booster is recommended 3 years after the initial doses.

**Cholera**

Estimates indicate 5 million to 7 million cholera cases worldwide annually, with more than 100,000 deaths. The disease is transmitted orally via water and food. Death rates during an epidemic can be high among those with severe cholera and poor treatment.\textsuperscript{58} Proper rehydration therapy decreases the mortality rate to < 1\%. The risk of contracting cholera is low for travelers (0.2 to 13/100,000), but higher for expatriates. During the 1991 epidemic in Lima, the estimated incidence of cholera among US embassy personnel was 44 per 100,000 population per month of exposure.\textsuperscript{59} There are two oral cholera vaccines (OCVs): a killed whole-cell *Vibrio cholerae* 01 with a recombinant B-subunit of cholera toxin (WC/rBS) vaccine, and a live attenuated *V. cholerae* 01 strain (CVD 103-HgR) vaccine. Both types of vaccine are extremely safe. The protective efficacy of the inactivated vaccine after two doses is 85\% to 90\% at 6 months, and 62\% at 12 months.\textsuperscript{60} Although 95\% seroconversion and protection were demonstrated in volunteers in the United States, the efficacy of the live vaccine could not be established in the field.\textsuperscript{61} The killed vaccine is taken in two doses, 7 to 42 days apart, with a booster dose every 2 years for adults and after 6 months for children. The live vaccine requires one oral dose with a booster dose every 6 months. Although cholera vaccination is not recommended for travelers, it can be considered for expatriates who will be working in areas with an ongoing epidemic or working in refugee camps with a high risk of epidemics. The WHO recommends the use of OCVs in certain endemic and epidemic situations.\textsuperscript{62}

**Tuberculosis**

The risk for long-term residents is estimated to be similar to that for the local population in the host country, at 1\% to 3\% per year.\textsuperscript{63} In a prospective study in long-term travelers from the Netherlands in developing countries, the incidence of infection measured by PPD conversion was 2.8/1,000 personmonths of travel and 7.9/1,000 personmonths for health care workers.\textsuperscript{64} Expatriate physicians working in medical settings exposed to cases with tuberculosis may have a similar risk of acquiring infection with *Mycobacterium tuberculosis* as Peruvian physicians exposed to a large number of tuberculosis cases at a public hospital, who had a 17\% annual PPD conversion rate and a high incidence (2\%) of symptomatic tuberculosis.\textsuperscript{65} Upon redeployment to the United States, from Guantanamo Bay in Cuba in 1995, 5\% of a military police unit had positive tuberculin skin test (TST) results.\textsuperscript{66} This is a substantial relative risk, but still a modest absolute risk, as only a small proportion will develop the disease.\textsuperscript{67}

Tuberculosis prevention in long-term expatriates is based on risk reduction measures and TST prior to departure and upon return to identify PPD conversion as a marker of infection, so that preventive therapy can be proposed. However, TST is a weak diagnostic tool, with problems in application and interpretation.\textsuperscript{68} In this highly mobile population, compliance with the testing procedure may be low: only 61\% of travelers to countries with a high tuberculosis incidence were compliant with the screening procedure; of those for whom data were available, 33\% of the compliant travelers required extra calls.\textsuperscript{69}

BCG is the only vaccine currently licensed for the prevention of tuberculosis. However, its efficacy against tuberculosis subsequent to infection with *M. tuberculosis* is incomplete. The vaccine protects children effectively against the generalized forms of the disease (meningeal and miliary tuberculosis) but not against pulmonary disease.\textsuperscript{68} The vaccine should be considered in small children residing in a region endemic for tuberculosis as well as for adults at high risk of contracting multidrug-resistant tuberculosis, such as health care workers and people visiting prisons.\textsuperscript{69}

**Influenza**

The risk of exposure to influenza abroad depends on the time of year, the destination, and the occurrence of influenza epidemics. In the southern hemisphere, influenza activity increases from April to September, but influenza can occur throughout the year in the tropics. To date, there are few data on influenza infection in travelers or expatriates. A longitudinal study demonstrated an incidence rate of 1.0 influenza-associated febrile events per 100 personmonths abroad.\textsuperscript{70} Seroconversion for influenza was demonstrated in 3\% of all travelers and in 23\% of febrile travelers tested. In 115 pilgrims who participated in the Hajj in 2003, the seroconversion-based influenza attack rate was 38\% (44/115).\textsuperscript{71} Data have shown
that influenza is associated with long-term travel >30 days. Following the general recommendations for influenza vaccination in the northern hemisphere, expatriates at high risk for complications of influenza (those >65 years of age, those with chronic disease, and immunocompromised persons) should consider yearly vaccination with the appropriate influenza strain when posted to the tropics and to the southern hemisphere. The vaccine used should have the appropriate selection of antigens corresponding to the circulating strains in the destination considered. Southern hemisphere vaccines are now becoming available in the northern hemisphere. The vaccine has an efficacy of 70% to 90% in healthy adults less than 65 years of age, but efficacy is lower in the elderly. It is effective in preventing secondary complications.

**Anthrax and Smallpox**

These vaccines are not commercially available, and have been used only for the military and health professionals who could be exposed to biological warfare or a terrorist attack. These will not be discussed in this review, as the possibility of using them for the general expatriate population is quite remote.

**Infants and Children**

Infants and children should be up to date with regard to routine vaccinations (see Table 3). The schedule of routine immunizations can be accelerated to provide maximal coverage during the stay overseas. There are vaccines for which special pediatric formulations or doses need to be used for certain age groups, such as those for hepatitis A, hepatitis B, hepatitis A and B, TBE and JE. Infants and children >9 months of age traveling to yellow fever-endemic areas should be vaccinated. Infants under the age of 9 months are at high risk of developing encephalitis as a result of yellow fever vaccination. Of 17 reported cases, 14 occurred in infants under the age of 4 months. Infants between 6 and 9 months of age should be immunized only when they travel to areas of ongoing epidemic yellow fever, especially when adequate protection against mosquitoes is not possible.

Usually, the hepatitis A vaccine is given from 1 year of age. Immunoglobulin can be given as passive hepatitis A prophylaxis in children who depart less than 2 weeks after receiving the hepatitis A vaccine, and in children under 2 years of age in countries where the vaccine is not licensed for those under this age. Infants can be vaccinated against hepatitis B from birth onwards. For children up to 16 years of age, a hepatitis B vaccine has been developed that requires half the adult dose. Children under 16 years of age need only two doses of the combined hepatitis A and B vaccine at months 0 and 6. The polysaccharide vaccines against meningococcal meningitis are poorly immunogenic in children less than 2 years old. Repeated doses are not given, because of the possibility of induction of immunologic hyporesponsiveness. Currently, the more immunogenic conjugated vaccines are commercially available only for serogroup C.

JE vaccine and TBE vaccine are generally not used below the ages of 1 and 6 years respectively. Children love playing with animals, so they are at increased risk of being bitten. They should be vaccinated against rabies when residing in endemic areas. No age limitations exist to its administration. There are no uniform guidelines on vaccination against tuberculosis. BCG vaccine provides good protection against complications of tuberculosis in the first year of life. In countries with high tuberculosis prevalence, infants are generally immunized as soon after birth as possible with a single dose of BCG. BCG should be considered for infants under 6 months of age traveling in an area with high incidence.

**Pregnant Women**

Since a considerable proportion of departing expatriate couples are in their procreative years, vaccination of the spouse while pregnant and during breast-feeding are of primary importance. Vaccination during pregnancy is indicated in situations where exposure is highly probable and the disease poses a greater risk to the woman or fetus than does the vaccination. Vaccinations should be avoided in the first trimester of pregnancy, due to the uncertain effect of the vaccine on the developing fetus. Live vaccines are contraindicated during pregnancy, except in special circumstances. Yellow fever vaccine should not be given during pregnancy, unless travel to a high-risk area is unavoidable. Breast-feeding is not a contraindication for yellow fever vaccination. The MMR vaccine should not be given to pregnant females or those planning to become pregnant within 1 month. Breast-feeding is not a contraindication to MMR vaccination of either a woman or an infant.

**The Immunocompromised**

Being immunocompromised is not an absolute contraindication for an extended stay overseas, but there may be an increased risk of acquiring or having more severe forms of certain endemic diseases. Adequate immunization is even more important. Live vaccines, such as that for yellow fever, may be contraindicated, according to the level of immunosuppression, and should be considered only when there is a substantial risk of contracting the disease.
Conclusions

Many expatriates and their dependants working in the developing world may be at risk of acquiring infectious diseases. Being posted to remote places, with reduced access to medical services having adequate diagnostic facilities and effective means of treatment, may put them at higher risk of complications and more severe outcomes. Vaccination is one of the most effective means of prevention, and there are now many very effective vaccines available, as reviewed in this article, to prevent expatriates from acquiring endemic or epidemic diseases in the places where they will be working. Being incapacitated or sick while in the field may cause serious disruption to project activities and impose extra workload on the team. It may result also in repatriation, with further extra direct and indirect costs to the organization. Predeparture advice and preparation to promote risk reduction behavior, coupled with adequate support in the field, are key ingredients to ensure effective and successful activities of collaborators. Institutions and organizations sending expatriates to developing countries have a clear responsibility, and it is in their own interests to promote the health of their employees working abroad.

Declaration of Interests

An unrestricted grant has been allocated by sanofi pasteur to write this article. JAD and FC have no interests to declare. LL has received funding for research, speaking, teaching and training from Berna Biotech, GlaxoSmithKline, Novartis, and sanofi pasteur.

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