Introduction

Singapore is at considerable risk from an explosive epidemic of human immunodeficiency virus (HIV) infection and associated health problems. An increasing influx of workers from countries of high HIV-endemicity, as well as the frequent exposure of well-travelled Singaporean citizens to commercial sex workers in neighbouring countries, are major areas of concern. The high background incidence of tuberculosis (TB) in Singapore adds further concern, as the two infections have shown a potential catastrophic interaction in many developing countries and impoverished inner city areas. On the other hand, Singapore is a small country with sophisticated health care and communication systems, and was forewarned by the nascent HIV epidemic abroad. Its efforts to limit the impact of HIV represent an interesting case-study.

Epidemiology

The first case of human immunodeficiency virus (HIV) infection in Singapore was confirmed and reported in 1985. The first case of acquired immunodeficiency syndrome (AIDS) was diagnosed in 1986. Since then there has been an increase in the number of cases of HIV and AIDS (Fig. 1). At 31 December 1996, a cumulative total of 558 Singapore residents had been reported as having been infected, of whom 186 (33 per cent) had died, 97 (17 per cent) were alive with AIDS, and 275 (49 per cent) had asymptomatic HIV infection.

The number of cases reported with HIV infection was 55 in 1995 (18.4 per million population) and 47 in 1996 (15.4 per million population). In contrast, the incidence of AIDS has consistently increased from 0.4 per million in 1986 to 30.2 per million population in 1996. Concurrently, among all new notifications with HIV infection to the National HIV Registry, the proportion notified with AIDS has increased from 14 per cent in 1986 to 66 per cent in 1996. Of the total 92 AIDS cases notified in 1996, only 28 (30 per cent) were previously known to be infected with HIV, whereas 64 (70 per cent) were previously unknown to the health service, and presented for the first time because of occurrence of an AIDS-defining illness. This suggests a substantial underestimation of the prevalence of HIV infection in Singapore. The proportion of people who presented late in the course of HIV infection in 1996 was similar to that observed in the preceding three years, ranging from 55 to 71 per cent.

There were 57 deaths among persons with AIDS in 1996, representing a mortality rate of 18.7 per million population. In a recent review of 50 consecutive patients with HIV infection presenting to the Singapore General Hospital, median survival from diagnosis of AIDS of those with and without an AIDS-defining illness at first presentation was 399 and 822 days, respectively. In contrast, a 1990 review of the first 50 patients in Singapore found median survival from the time of AIDS diagnosis to be only 7 months. Survival has improved with earlier recognition and diagnosis of HIV infection, earlier treatment and the continual advances in therapy.

The male:female ratio has decreased from 24:1 for the first 50 HIV-infected patients diagnosed up to 31 May 1990 to a cumulative male:female ratio of 10:1 in 1996. Eighty nine per cent of all cumulative cases were aged below 50 at the time of diagnosis; the majority were aged between 20 and 39 years. Interestingly, the proportion aged 50 and above increased from 5 per cent in 1991 to 17 per cent by mid-1996. The median survival among older patients from the time of diagnosis with AIDS was substantially shorter at only 3 months, because of late presentation, under-recognition at presentation and possible faster disease progression. Of the 558 persons reported with HIV or AIDS, 67 per cent were single, 25 per cent married, and 8 per cent divorced or widowed. The most common occupational category was service and sales workers (19 per cent), followed closely by managers and professionals (18 per cent; Table I).
The predominant mode of transmission was sexual, responsible for 95 per cent of the cases up to 1996. The cumulative proportion arising from heterosexual contact increased from 21 per cent for the early cases to 68 per cent in 1996. Injection-drug use accounted for 11 cases (2 per cent), four of whom were diagnosed in 1996. One case of infection occurred because of a contaminated blood transfusion received in the early 1980s while the individual was in the United States, whereas no cases have been attributable to transfusion of blood products in Singapore. There have been five cases caused by renal transplants carried out overseas, the last diagnosed in 1995. Two cases of perinatal transmission were diagnosed, in 1991 and 1996.

It was identified early on that a significant risk factor for HIV infection among the local population was contact with commercial sex workers during travel to other countries. Almost three-quarters of the patients reviewed by Chew et al. in 1990 gave a history of such high-risk sexual exposure. This trend has persisted and sex with commercial sex workers remains the single most important risk factor for HIV infection in Singapore.

Although the incidence of tuberculosis in Singapore is still moderately high, averaging over 50 cases per 100,000 population for the past decade, HIV is not a significant contributor to the overall burden of tuberculosis. The prevalence of HIV seropositivity among tuberculosis notifications to the National TB Registry in 1995–1996 was found to be only 1 per cent. The same study did not find any association between drug resistance and HIV. In reviewing these data, it was found that of 100 HIV-positive patients who have developed tuberculosis as an opportunistic infection, so far only five had drug-resistant strains, of which three cases represented initial resistance, and two acquired resistance. This figure is very similar to the proportion of all tuberculosis cases notified with resistance, which was 4.3–5.5 per cent over the past 5 years.

**Table 1** Distribution of persons with HIV–AIDS by occupation, 1985–1996

<table>
<thead>
<tr>
<th>Occupational classification</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service and sales workers</td>
<td>106 (19)</td>
</tr>
<tr>
<td>Managers and professionals</td>
<td>98 (18)</td>
</tr>
<tr>
<td>Technicians</td>
<td>39 (7)</td>
</tr>
<tr>
<td>Production craftsmen</td>
<td>52 (9)</td>
</tr>
<tr>
<td>Machine operators and assemblers</td>
<td>46 (8)</td>
</tr>
<tr>
<td>Cleaners and labourers</td>
<td>46 (8)</td>
</tr>
<tr>
<td>Clerical workers</td>
<td>29 (5)</td>
</tr>
<tr>
<td>Others</td>
<td>67 (12)</td>
</tr>
<tr>
<td>Unemployed</td>
<td>71 (13)</td>
</tr>
<tr>
<td>Unknown</td>
<td>4 (1)</td>
</tr>
<tr>
<td>Total</td>
<td>558 (100)</td>
</tr>
</tbody>
</table>

Source Ref. 3.

**Singapore’s response**

Primed by awareness of the evolving HIV pandemic abroad, the Ministry of Health moved swiftly after identification of the first case in Singapore by formulating the National AIDS Control Programme in 1985. An expert committee, the AIDS Task Force, provides scientific advice to the Ministry on the management of HIV-infected persons, epidemiology of the disease, development of patient services and dissemination of information. Its multidisciplinary composition includes professionals in public health, epidemiology, health education, laboratory science and clinical medicine. Another committee,
the National Advisory Committee on AIDS, provides a channel for community feedback on the national response. In recognition of the key role of health education and behaviour modification in the control of HIV infection, an AIDS Education Work-Group was also constituted by the Training and Health Education Department of the Ministry of Health.

Singapore’s response to the HIV epidemic, as enunciated in the National AIDS Control Programme, was dictated by the following imperatives: (1) protection of the supply of blood and blood products; (2) prevention of transmission by education of the general public and at-risk groups; (3) prevention of transmission by medical screening of foreign nationals seeking employment here; (4) epidemiologic surveillance and research, and defaulter and contact-tracing by maintenance of a central HIV/AIDS registry; (5) cost-effective and holistic management of patients with HIV/AIDS; (6) supportive legislation for public health control measures.

Protection of the blood supply

Since the onset of the HIV epidemic in Singapore in 1985, this component of the national response has implicitly been accorded the highest priority, with zero-tolerance for transfusion-related HIV transmission. Even a single case may have a destabilizing impact on public confidence throughout the health care system. After the ELISA test, which detects HIV antibodies, became commercially available in 1985, virtually immediately screening of all donated blood was instituted by the Blood Transfusion Service. (L. T. D. Teo, personal communication, 1997). The magnitude of the tragedy averted by the expedient adoption of this screening policy is discernible in the sobering statistic that in the early stage of the epidemic in Singapore, 24 per cent of cases were diagnosed when they presented themselves for blood donation. As it turned out, no case of HIV infection has been linked to transfusion of blood products locally: the only instance of transfusion-related HIV infection to date being the case mentioned above, caused by a blood transfusion received abroad.

The Singapore Blood Transfusion Service has since its inception eschewed monetary incentives for blood donation, choosing instead to rely completely on voluntary donations. This policy prevents the theoretical hazard of a pecuniary reward attracting high HIV-risk injection-drug users attempting to ‘sell’ their blood to support their addiction. The introduction in 1987 of a compulsory questionnaire-cum-declaration to be completed before blood donation (L. T. D. Teo, personal communication, 1997) has also deterred individuals at risk of being infected with HIV, who might otherwise seek covertly to obtain free screening for the disease by presenting themselves as blood donors. Possible prosecution under the provisions of the Infectious Diseases (Amendment) Act of 1992 encourages self-exclusion, thereby increasing the negative predictive value of serologic testing. This two-stage process strongly ensures the safety of the blood supply.

Facilities for autologous blood donation exist as private enterprises that offer an alternative for individuals undergoing elective surgery who seek greater assurance, though at a cost for those individuals. Notwithstanding the stringent preventive measures, every claim by an HIV-positive individual of either blood donation or receipt of a transfusion at any time in the past is investigated by the Singapore Blood Transfusion Service (L. T. D. Teo, personal communication, 1997). Transfusion records serve as a link between donors and recipients of blood products. These retrospective analyses have thus far not implicated local blood transfusions as a cause of HIV transmission.

Education of the general public and at-risk groups

In light of the predominantly sexual route of transmission of HIV infection in Singapore, the difficult task of influencing people to modify their sexual behaviour has become a major focus of educational programmes. Furthermore, in view of the primarily heterosexual transmission, health education programmes have been extended to include the general public in an attempt to interrupt HIV transmission. Unfortunately, despite efforts by the Ministry of Health to achieve a reduction in the incidence of HIV by promoting the adoption of safe sexual practices, condom use is still commonly spurned among groups with risky sexual behaviour. Even more disturbing is that unprotected sex was found to be relatively common among a cohort of final-year medical students in 1990, despite their high educational level and very specific knowledge of HIV.

The Training and Health Education Department of the Ministry of Health carries out the key role of co-ordinating, planning and implementing the health promotion and health education effort aimed at the general public. The Department, which has previously undertaken other major national campaigns for the control of smoking and prevention of cancer, uses a variety of approaches and methods, including mass media advertising, public campaigns, and activities tailored to specific target groups, to disseminate health messages. An equally important role fulfilled by the Department is the facilitation of similar activities by others. Thus members of the Department serve as advisors to other individuals or organizations. The Department is responsible for the training of ‘facilitators’ such as teachers and company nurses to conduct AIDS education activities, thus extending the effective reach to groups as diverse as students and factory workers.

The fact that HIV infection is not externally discernible is emphasized, and that therefore casual sex, no matter how attractive, is a behaviour that puts one at risk of becoming infected with HIV. Promotion of positive family values, including fidelity to one’s partner and responsibility towards children by avoidance of such risky behaviour, are the main educational messages.
Medical screening of foreign nationals seeking employment

All foreign nationals seeking a work permit from the Ministry of Labour for employment in Singapore are required to undergo a medical examination that includes a chest radiograph as well as blood investigations for syphilis, HIV and hepatitis B; for females, pregnancy tests are also included. Negative HIV serology is one prerequisite for issue of a work permit. A repeat medical examination is similarly required for work permit renewal after a 2- or 3-year term. This screening programme has detected a significant number of HIV-positive applicants from countries with a high endemicity of HIV infection. The legislative provisions for the conduct of such screening reside in the Immigration Act of 1959\(^\text{16}\) and the Infectious Diseases Act of 1976.\(^\text{17}\)

The National HIV Registry

Maintenance of the National HIV Registry, receipt and processing of HIV notifications, and the collation and compilation of data for the Ministry of Health are functions carried out by the Department of Clinical Epidemiology (DCE) of the Communicable Disease Centre in Tan Tock Seng Hospital. Compulsory notification of specified infectious diseases of public health importance had already been required by the Infectious Diseases Act of 1976.\(^\text{17}\) In 1985, HIV infection and AIDS were added to the First Schedule of diseases required to be notified. Failure of medical practitioners or persons in charge of a laboratory to do so is an offence punishable by a fine or imprisonment, though to date no clinical or laboratory practitioner has been prosecuted under the Act. Instead, delinquent notifications are dealt with administratively through repeated telephone reminders by DCE staff, which eventually always obtain the desired notification. The DCE also requires doctors to complete a more comprehensive HIV Surveillance Data Form. Non-submissions and incomplete or erroneous submissions are similarly pursued to conclusion.

Notified cases are entered as individual records in the National HIV Registry Database, which in addition to recording personal particulars and details of the initial diagnosis, is regularly updated with events such as progression of HIV to AIDS, occurrence of opportunistic diseases and death. In view of possible co-infection with HIV and tuberculosis,\(^\text{16,19}\) the HIV Registry is automatically linked to the National TB Registry and lists HIV-positive individuals who are notified with tuberculosis. This increases the completeness of AIDS notifications. All information remains strictly confidential: access to the data is restricted and patient anonymity is maintained in external reports.

The DCE also collates and reports the results from annual HIV seroprevalence surveys using unlinked blood samples collected for purposes other than diagnosis of HIV from seven sentinel sources: sexually transmitted disease clinic attenders, hepatitis B patients, inmates of Drug Abuse Rehabilitation Centres, antenatal clinic attenders, forensic blood specimens and biochemistry blood specimens.

Centralized management of patients with HIV and AIDS

The Communicable Disease Centre (CDC) at Tan Tock Seng Hospital provides for the multidisciplinary management and follow-up of patients notified with HIV or AIDS. CDC has had a long-standing history as the main treatment centre for infectious diseases, and is the designated isolation centre for patients with infectious diseases of public health importance under the provision of the Infectious Diseases Act of 1976.\(^\text{17}\)

With the HIV–AIDS epidemic, CDC assumed an important role as the primary centre for provision of holistic care to patients with HIV infection and AIDS. The critical mass of professionals and patients increases the scope of research in HIV, and through the use of clinical treatment protocols facilitates the achievement of the best outcomes. Patients receive personal and financial counselling, and help in applying for financial assistance. Health education talks are also organized for patients and their family members on various aspects of HIV and AIDS. ‘Health advisers’ counsel patients and their contacts and are involved with research. This results in more accurate and complete data to guide efforts at prevention and control of transmission, and promotes better compliance with treatment. Health advisers also re-establish communication with patients who default from follow-up.

An HIV and TB programme assistant tracks and reinforces compliance with antituberculous treatment in HIV-positive patients with concurrent tuberculosis by liaising with patients and out-patient clinics. The success of this personal effort is apparent in the high treatment completion rates (I. Verghese, personal communication, 1997) and the cited low incidence of drug-resistance in HIV-infected patients with tuberculosis. The programme assistant also facilitates collaboration between a patients’ self-help group, local non-governmental organizations and volunteer groups, which provide emotional support, counselling and practical help to patients in times of need.

Legislation

As is true for other serious communicable diseases in Singapore, the public health response to HIV is supported by laws that make control measures enforceable. Three important facts have influenced the legislative process: HIV infection is predominantly a direct consequence of human behaviour (i.e. sexual practices and use of injection drugs). It also bears a grave prognosis. Most particularly, it is associated with social stigmatization, which, in contrast to other infectious diseases, dictates a uniquely delicate balance between opposing demands of the individual right to freedom and strict confidentiality of information, and the community right to safety and protection from health hazards.
Pre-existing legislation pertaining to the prevention and control of infectious diseases had to undergo expansion, revision and reinterpretation to support control measures specific for HIV such as notification, and to address difficult ethical issues such as confidentiality. The relevant legislation is found mainly in three Acts of Parliament: the Infectious Diseases Act of 1976,\textsuperscript{17} the Infectious Diseases (Amendment) Act of 1992,\textsuperscript{11} and the Immigration Act of 1959.\textsuperscript{16}

Suspected carriers are legally obliged to submit to medical examination, though the law prohibits the disclosure of identity or other personal particulars relating to any person infected with HIV except under certain specified conditions.\textsuperscript{20} Partner notification is not carried out because of the legal requirement to maintain confidentiality, but infected persons are strongly encouraged to inform their sexual partners so that they may seek testing.

**Paying for the treatment of HIV and AIDS**

A worrisome trend of increases in the costs of in-patient and out-patient care for HIV infection has been noted, accentuated by the expensive combination anti-retroviral regimes which are now the standard care for HIV infection. Meeting lifetime costs of treatment is likely to impoverish many patients, as the charges for such drugs have to be borne in full by the patients themselves. Health care financing in Singapore is facilitated by the Medisave section of the Government's Central Provident Fund scheme, under which a fixed portion of the monthly salary of all employees is pre-deducted and deposited into compulsory savings, earmarked exclusively to pay for in-patient medical bills. This account is a valuable resource to an HIV patient in meeting the considerable expense of his or her treatment. Government subsidies granted in general to all patients choosing accommodation in lower-cost wards also help to reduce the charges for in-patient treatment. Where other resources are exhausted and a patient meets certain criteria, a special subsidy may also be sought from Medifund, an endowment fund administered by the Government for patients unable to meet the costs of 'basic health care'.

No official data are available on the average expenses incurred by patients or the total cost to the country per case of HIV infection. However, the predominance of males in their economically most productive years,\textsuperscript{3} the rising incidence\textsuperscript{5} and the increasing costs of treatment regimes predict a significant financial burden if present trends continue. In response to the escalating costs, steps are currently being taken to conduct cost-effectiveness analyses of HIV-treatment to assist with cost-control and to maximize use of limited resources, allowing policy-makers to plan for the appropriate allocation of resources based on forecasts of disease trends.

**Conclusion**

Whether the reduction in notifications of HIV infection noted in the past few years represents a true arrest or reduction in HIV incidence remains to be seen. Any decrease in the resulting number of AIDS cases will, of course, lag by some years. In any event, this does not absolve us from making careful preparations to meet the contingency of a continuing increase in incidence of HIV infection and AIDS cases.

Two potentially tragic outcomes have been averted by HIV containment strategies adopted so far by the health system. The first was the early threat of transfusion-related HIV infection, which was successfully prevented by the immediate adoption of screening of all blood donors for HIV antibodies. The second and continuing threat is of a resurgent epidemic of tuberculosis and the emergence of multidrug-resistant strains fuelled by HIV, thus far controlled by the high priority given to monitoring and assurance of treatment compliance among HIV patients with tuberculosis.

Singapore's health care system is at present being mobilized to meet a third and equally ominous threat: the rising costs of treatment for HIV and AIDS. The challenge is to achieve cost-effectiveness and cost-control within the HIV programme, while arriving at a rational, equitable and ethical formula for the allocation of resources to the programme from the overall health budget.

**Acknowledgements**

We wish to acknowledge the kind assistance of the Singapore Blood Transfusion Service, the Epidemiology & Disease Control and Training & Health Education Departments of the Ministry of Health, Dr Ian Snodgrass, Iris Vergheze and Soh Ai Keow in the preparation of this manuscript.

**References**


8 Lee CC, Leo YS, Snodgrass I, Wong SY. The demography, clinical manifestations and natural history of human immunodeficiency virus (HIV) infection in an older population in Singapore. (Submitted.)


11 Infectious Diseases (Amendment) Act, No. 5 of 1992, Statutes of the Republic of Singapore.


*Accepted on 14 October 1997*