India: Towards Universal Health Coverage 1

Continuing challenge of infectious diseases in India

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In India, the range and burden of infectious diseases are enormous. The administrative responsibilities of the health system are shared between the central (federal) and state governments. Control of diseases and outbreaks is the responsibility of the central Ministry of Health, which lacks a formal public health department for this purpose. Tuberculosis, malaria, filariasis, visceral leishmaniasis, leprosy, HIV infection, and childhood cluster of vaccine-preventable diseases are given priority for control through centrally managed vertical programmes. Control of HIV infection and leprosy, but not of tuberculosis, seems to be on track. Early success of malaria control was not sustained, and visceral leishmaniasis prevalence has increased. Inadequate containment of the vector has resulted in recurrent outbreaks of dengue fever and re-emergence of Chikungunya virus disease and typhus fever. Other infectious diseases caused by faecally transmitted pathogens (enteric fevers, cholera, hepatitis A and E viruses) and zoonoses (rabies, leptospirosis, anthrax) are not in the process of being systematically controlled. Big gaps in the surveillance and response system for infectious diseases need to be addressed. Replication of the model of vertical single-disease control for all infectious diseases will not be efficient or viable. India needs to rethink and revise its health policy to broaden the agenda of disease control. A comprehensive review and redesign of the health system is needed urgently to ensure equity and quality in health care. We recommend the creation of a functional public health infrastructure that is shared between central and state governments, with professional leadership and a formally trained public health cadre of personnel who manage an integrated control mechanism of diseases in districts that includes infectious and non-infectious diseases, and injuries.

Introduction

Macroeconomic progress

India, one of the poorest countries in the 20th century, has become the fifth largest economy in the 21st century through enhanced industrial output and development of innovative technology—eg, information, biopharmaceutical, nuclear, space satellite, and lunar probe. This macroeconomic growth has not resulted in the equitable distribution of benefits, particularly economic and health-related benefits. Although a few remarkable achievements have occurred in relation to the control of infectious diseases, India has not succeeded in controlling many old, new, or resurgent infectious diseases. The cause of this deficiency is the health system, which, although focused on technologically advancing medical care for the urban elite population, lacks an adequately functional public health infrastructure that is essential for prevention of disease in all communities.[1,2]

Key messages

- Although the burden of infectious diseases has decreased as a result of overall socioeconomic progress and increasing use of vaccines and antimicrobials in the past 60 years since independence from colonial rule, they still contribute about 30% of the disease burden in India.
- Only a few infectious diseases are prioritised in the vertical control programmes managed by the central government, and even among these diseases only the control of HIV and leprosy seems to be successful but not that of diseases such as tuberculosis, malaria, and visceral leishmaniasis.
- Infectious diseases that are not in the vertical control programmes are mostly neglected, with no formal monitoring or control system at the population level.
- Functional integration of vertical programmes and their coordination with the health-care system, which is managed by state governments, is needed for efficient and sustainable reduction of the burden of a wide range of infectious diseases.
- Case-based disease surveillance, generated through health-care personnel in the public and private sectors, and public health response at the district level, as part of a functional public health infrastructure, are urgently needed for effective control of all infectious diseases.
- The public sector health-care network is overwhelmed with preventable morbidity from infectious and other diseases, encouraging growth of largely unregulated private commercial health care that entails large out-of-pocket expenditures by families.
- For a formal cadre of public health personnel at district, state, and national levels, reorganisation of the system and adequate training programmes will be necessary to control infectious diseases and link this effort with control of the increasing burden of non-infectious diseases and injuries that are already major causes of death and economic loss.

Search strategy and selection criteria

We identified seminal articles published in peer-reviewed journals and reports that were pertinent to the control of infectious diseases, using inhouse expertise, consultations with other experts on this subject, and search of the key databases, including PubMed and archives of the International Society for Infectious Diseases. The websites of central and state governments, and of international agencies were accessed for relevant reviews, guidelines, and databases. The exclusion and inclusion criteria for the papers were deliberately kept flexible. The scope of the review was increased on the basis of findings from the review of key papers and reports. Relevant published and unpublished technical documents were accessed for review.

There are reasons for this paradox of neglect of infectious diseases despite remarkable economic progress. In India, popular beliefs about the origins of diseases range from imbalance of internal body forces (doshas) to supernatural causes that cannot be treated by use of modern medicine. Microbial pathogens are not recognised in traditional medicine and, hence, cleanliness of water and food is not understood as the absence of microorganisms.[3] The popular understanding is that individuals are solely responsible for their own health, and illnesses are often not thought to be within human control and hence are unpredictable and unpreventable. These factors largely account for why public health is neglected by political leaders and not demanded by the people, including those who are well educated.

In addition to a population of more than 1·16 billion individuals, 26 million births every year replenish the hosts for many anthroponoses. Open-field defecation continues to be widespread in rural and urban poor communities, and low-quality engineering is used to remove piped or open sewage in urban settings. Both lead to faecal contamination of the source or supply of drinking water. Risks of zoonoses persist because of the close contact with animals for economic necessity, respect for life, and indifference to or neglect of the environment. These are formidable challenges even if we had an adequate public health programme, but in its absence they cannot be addressed systematically.

In 2009, India ranked 134th among 182 countries in the Human Development Index (a composite measure of health, education, and living standards) because of underinvestment in health and education, which are the major components of human development.[4] Since the economy has improved, India must invest heavily in public health and prevent infectious diseases for which interventions are already available. Organised disease prevention and equitable health care would ensure the entitlement of human rights (of life and health) for individuals, and would enhance national productivity as a result of a healthy population. The public health lessons learned from prevention of single-cause infectious diseases can guide future interventions against the increasing epidemics of chronic (non-infectious) diseases with several causes. In this review, we show the mismatch between the infectious diseases and the deficient responses, with the intention of encouraging a change in India's health policy and system so as to align them with what is required to substantially improve population health.

Strengths and weaknesses of health system

Management of the health system is shared between the central (federal) and state governments; health policies, regulatory functions, and control of diseases and outbreaks are the responsibility of the Government of India; health care and training of personnel are provided by the state. The Indian Government's Ministry of Health (MoH) functions as the Department of Health Services, Department of Family Welfare, Department of Health Research, and Department of Traditional Medical Systems, but has no Department of Public Health.[2] The state MoH has a Department of Medical Education in addition to a Department of Health Services and Department of Family Welfare, but has no Public Health Department, except in Tamil Nadu.[5]

The Indian Government uses two strategies for control of infectious diseases. First, it uses selective disease control (vertical) through special programmes: Revised National Tuberculosis Control Programme, National AIDS Control Programme, National Vector-Borne Diseases Control Programme, National Leprosy Eradication Programme, Universal Immunisation Programme, and National Poliomyelitis Surveillance Project. These programmes, controlled by the Department of Health Services or Department of Family Welfare, are virtually autonomous, each with its own central, state, and district officers, and field staff. Although this approach helps to improve the management of programmes, it is too expensive to be replicated for the control of other diseases. Another disadvantage of this method is that the programmes cannot be integrated with each other or with the health-care system, without which disease control cannot be efficient.

The second strategy is the provision of ad-hoc assistance for outbreak investigations and control. On invitation from states, teams from the National Institute of Communicable Diseases, a semiautonomous institution that is controlled by the Department of Health Services, go to the field. This method is inefficient for several reasons. Detection of signals is not noted through case-based disease surveillance, and recognition of outbreaks is often delayed. Although the media report the outbreaks, they tend to sensationalise, whereas the state's Department of Health Services tends to deny or underestimate the magnitude of the outbreak. The lack of real-time disease reporting is acutely felt in times of outbreaks in different parts of the country. In one instance, a large epidemic of meningococcal meningitis was investigated about 1 year after it began in the northeastern states.[6] In another instance, a large outbreak of hepatitis B was missed until about 70 people died as a result of it.[7] Both outbreaks were brought to the attention of the public by the media. The second strategy does not help control endemic infectious diseases, irrespective of the magnitude.

Tamil Nadu has a Department of Public Health, with a public health professional as the Director of Public Health and Preventive Medicine.[8] The state has a public health cadre, with state and district health officers, for whom training in public health is mandatory. This public health cadre offers a defined, highly valued, well remunerated, and respected career track.[5,8] Vertical disease control activities, primary health centres, and maternal and child health are supervised by public health

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For more on the **Ministry of Health and Family Welfare** http://www.mohfw.nic.in/

For more on **National health programmes** see http://mohfw.nic.in/healthprogmain.html

officers. Tamil Nadu leads in terms of achievements in nearly all of them.

The health system in cities is managed by local governments that are controlled by the Ministry of Local Administration, independently of the MoH. Such fragmentation leads to delays and errors in the attempts to control many infectious diseases, endemic or epidemic. Many cities still maintain special hospitals for contagious diseases that were established under colonial rule, and have not established modern public health programmes to prevent or control them.

Gaps in information gathering

The Public Health Act of 1897 has not been amended (a draft of the revised act is pending in Parliament); hence notifiable diseases are generally not reported. A real-time, efficient, and inexpensive surveillance of diseases in districts that are prone to outbreaks and are targeted for control, in both public and private-sector hospitals, has been successfully field tested.[9,10] It could not be scaled up because health care is the responsibility of the state, and outbreak control is mainly the responsibility of the federal government. Therefore, the Integrated Disease Surveillance Project, another vertical programme, supported by the World Bank, was established in 2004. It is not integrated with other vertical programmes or with health care, and is virtually ineffective yet for the control of infectious diseases.[11] Therefore, a badly designed solution does not achieve the desired result and also prevents the application of the right solution. WHO's Regional Office for South-East Asia reports monthly data for selected infectious diseases in member countries, but data from India are often reported as not available.[12]

For more on **the Integrated Disease Surveillance Project** see http://www.idsp.nic.in/

Civil law requires death registration before cremation or burial. Rural communities often ignore it; about 70% of deaths happen at home, and more than three-quarters of these without certification of the cause of death.[13] In urban communities, local health departments register death, but the information is not captured in the health-care system.[14] Autopsies are rarely done, except when a criminal case is registered. Invaluable data about frequency, age pattern, and causes of death are lost. To capture these data, a public health infrastructure must include all administrative units. The neglect of the relevant civil law shows the widely held belief that life events are externally directed and not changed by human endeavour.

Another potential source of data for infectious diseases is the diagnostic laboratory. However, primary and secondary public sector health-care networks have no access to microbiology laboratories (except for blood and sputum smears to test for the presence of malarial parasites and acid-fast bacilli). The Medical Council of India does not recognise infectious diseases as a specialty for postgraduate medical education, resulting in inadequately prepared teachers who seldom use evidence-based diagnosis of these diseases in undergraduate teaching, and thereby perpetuate low demand and supply of laboratory services. Quality-assured support for microbiology laboratories is restricted to a few medical-care institutions.[15] Antibiotics are sold over the counter, overused, and misused, leading to increasing drug resistance.

For more on **the Medical Council of India's postgraduate medical education regulations** see http://www.mciindia.org/know/rules/rules_pg.htm

Estimates of disease burden are thus obtained from fragmentary databases, mostly generated through primary health centres that cater to only a small proportion of people with illnesses. Denominator-based data are available only from surveillance of polio infection and yearly surveys of HIV infection. Within these limitations, the estimates by the Global Burden of Disease Project (table) suggest a 15-times greater burden of infectious diseases per person in India than in the UK in 2004, and that about 30% of the disease burden in India is attributable to infections.[16] These data do not capture several other infectious diseases of clinical and public health importance.

	Total disease burden*	Infectious disease burden*
Lower respiratory infections	6·9%	25·8%
Diarrhoeal diseases	5·7%	21·3%
Tuberculosis	2·4%	8·9%
Measles	1·6%	6·1%
Pertussis	1·4%	5·1%
HIV/AIDS	1·3%	4·7%
Lymphatic filariasis	0·9%	3·2%
Meningitis	0·8%	2·9%
Maternal sepsis	0·5%	1·7%
Tetanus	0·4%	1·7%
Leishmaniasis	0·4%	1·5%
Gonorrhoea	0·4%	1·4%
Chlamydia	0·4%	1·3%
Syphilis	0·2%	0·8%
Malaria	0·2%	0·7%
Hepatitis B	0·2%	0·6%
Japanese encephalitis	0·1%	0·4%
Otitis media	0·1%	0·4%
Upper respiratory infections	0·1%	0·3%
Ascariasis	0·1%	0·3%
Trichuriasis	0·1%	0·3%
Dengue	0·1%	0·2%
Hepatitis C	0·1%	0·2%
Hookworm disease	<0·1%	0·1%
Leprosy	<0·1%	0·1%
Diphtheria	<0·1%	0·1%
Trachoma	<0·1%	0·1%
Poliomyelitis	<0·1%	<0·1%
Other infectious diseases	2·6%	9·8%
Total	26·9%	100%

*Estimated with disability-adjusted life years lost.

***Table*: Burden of infectious diseases for India in 2004 according to estimates from the Global Burden of Disease Study[16]**

Diseases specifically targeted for control

Success stories

Smallpox was eliminated in 1975 as part of the global effort for eradication. Before independence, dracunculiasis was widespread, affecting about 25 million people.[17] In 1983 (with about 40 000 cases in 12 000 villages), it was targeted for elimination through methods to break transmission between people and fresh-water cyclops; the last case was reported in July, 1996, in Jodhpur (Rajasthan) and WHO certified elimination in 1999.[17] Yaws, once prevalent in Andhra Pradesh, Madhya Pradesh, Maharashtra, and Orissa was eliminated by use of longacting penicillin according to the Government of India in September, 2006, but certification by WHO is awaited.[18]

India has a long and excellent history of leprosy care by non-governmental organisations and the National Leprosy Control Programme. In 1981, WHO targeted leprosy for global elimination (defined as a prevalence of fewer than one in 10 000 population) by 2000. India renamed this programme the National Leprosy Eradication Programme when the prevalence, measured by active case searches, was 5·7 per 10 000 population. Multidrug treatment allowed rapid microbiological cure, yet the elimination target for 2000 was missed. This target was then set for 2005 and achieved; thereafter active search of cases was stopped. The reported 65% reduction (from 456 000 to 161 457 during 1993–2005), unlike in neighbouring countries without a reduction during the same period—Bangladesh (from 6943 to 7882), Nepal (from 6152 to 6150), Sri Lanka (from 944 to 1924), and Indonesia (from 12 638 to 19 695)—deserves close scrutiny.[19] In 2007–08, prevalence was only 0·74 per 10 000 population, but the rate of new cases was 1·17 per 10 000 per year. Because of the inadequacies in health care, we fear resurgence might happen in the future.

The successful elimination of some infectious diseases was possible because of the availability of specific interventions. This success only reinforced the model of single-disease control in vertical projects without the establishment of a comprehensive public health infrastructure to address all infectious diseases where they arise.

The control of cluster of childhood infectious diseases—neonatal tetanus, pertussis, diphtheria, measles, and poliomyelitis—with the Universal Immunisation Programme is discussed by Paul and colleagues in this Series.[20] Since Japanese encephalitis is a significant problem among children in several states, vaccination against it has been introduced in the affected areas under the National Immunisation Programme. Diphtheria in children has re-emerged.[21] In 2010, India was one of four countries in the world in which poliovirus was still endemic, and the only country to not offer the globally recommended second dose of the measles vaccine.[22]

For more on **Japanese encephalitis** see http://india.gov.in/sectors/health_family/vector_borne01.php

For more on **endemic countries** see http://www.polioeradication.org/Infectedcountries.aspx

Tuberculosis

In 2009, India had 2 million new cases of tuberculosis, the highest for any country in the world, including 0·9 million smear-positive cases of pulmonary tuberculosis, and 280 000 deaths from tuberculosis.[23] The incidence of 168 per 100 000 per year has not decreased over the past two decades.[23] In the 1950s, widespread high prevalence of tuberculosis was confirmed by surveys using the tuberculin test and miniature chest radiographs.[24] In response, in the 1960s, the National Tuberculosis Control Programme (NTCP) for infant BCG vaccination and treatment of pulmonary tuberculosis through collaboration with health-care institutions in the districts, National Tuberculosis Institute for Training, and Tuberculosis Research Centre were established. Also, the BCG vaccine was produced locally. India had the opportunity through NTCP to control tuberculosis before the HIV epidemic happened. When assessed in 1990–92, the NTCP had not been successful; a revised NTCP (RNTCP) was established in 1993 in a few districts, with directly observed treatment, short course. Expansion of this treatment to the entire country was completed by 2006 (figure 1). The BCG vaccine showed no

For the **National Leprosy Eradication Programme** see http://www.nlep.nic.in

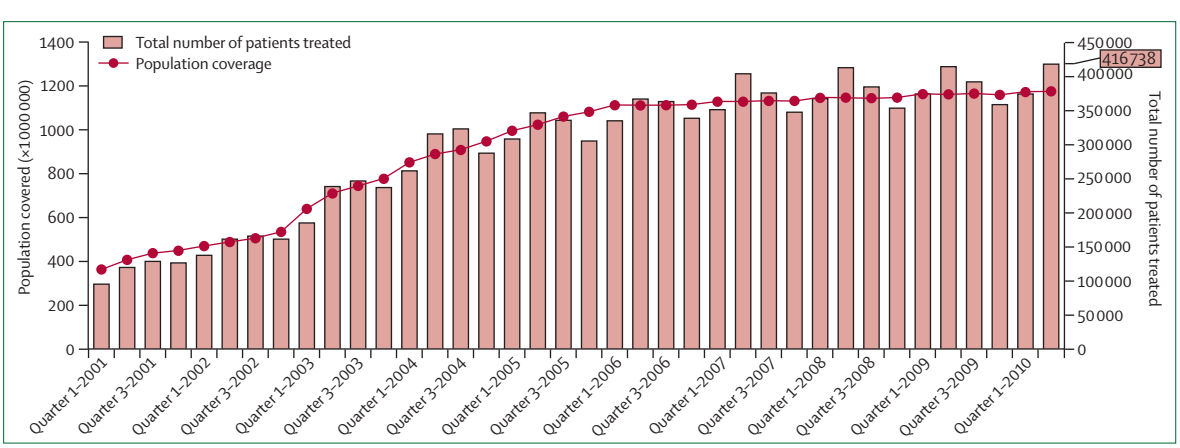

Figure 1: **Directly observed treatment, short course coverage in India for tuberculosis**
Reproduced with permission from TBC India.[25]

efficacy in primary or secondary prevention in a trial, hence it did not have a role in the control of tuberculosis.[26] The hoped-for collaboration with all health-care institutions has not happened even with RNTCP. HIV, detected in India in 1986, has complicated the control of tuberculosis.[27] Diabetes mellitus (increasing quickly in prevalence) is another risk factor for tuberculosis.[28] Overall, incidence of tuberculosis has not decreased.[29]

RNTCP operates in all states and districts.[25] The programme uses WHO's guidelines for estimating numbers of people with pulmonary tuberculosis, sputum-smear examination, drug regimen, and desired cure rate.[25] The benchmarks of 70% case detection and 85% microbiological cure have been achieved, and the programme increases rates of cure, decreases case fatality, and prevents emergence of drug resistance;[30,31] however, new cases continue to be detected without decline (figure 1).[25] Yearly rate of tuberculosis infection in children has remained at 1–2% per year since the 1970s, showing no reduction in three decades.[32,33] However, high coverage with BCG vaccine has reduced the rate of progressive primary tuberculosis—meningitis, pulmonary or disseminated tuberculosis in children—in the collective experience (anecdotal, unpublished) of colleagues who are paediatricians.

Prevalence is not uniform in the country. In one district in Tamil Nadu, active surveillance showed a prevalence of pulmonary tuberculosis of 605 culture-positive and 323 smear-positive cases per 100 000 population.[34] Smear tests missed more than half the infectious cases since the sensitivity has been reported as only 44%.[35] RNTCP screens an average of 140 people per 100 000 per year, thus missing many infectious individuals who are treated with non-standard regimens in private-sector health care, contributing to the drug resistance.[24,31,36,37] A cause for concern is the potential threat of extensively drug-resistant tuberculosis in India, with unregulated availability and injudicious use of the second-line drugs and no system to ensure adherence to standardised regimens and treatment for multidrug-resistant tuberculosis outside the RNTCP.[24,31] Although isolates of extensively drug-resistant tuberculosis have been reported in tertiary health-care institutions in Mumbai, Lucknow, Delhi, Vellore, and Thiruvananthapuram, none were detected by RNTCP until December, 2008.[38]

India needs an enhanced model for the control of tuberculosis.[29,39] District public health officers are needed to receive reports about all cases that are diagnosed in all health-care clinics in the district, and to link the reports with RNTCP for standardised case management. Computerised data should capture information about all health-care-based laboratory tests for tuberculosis, and all antituberculosis drugs dispensed by pharmacies. Access to a quality-assured microbiology laboratory is necessary so that the bacterium can be cultured and sensitivity tests can be done. Baseline yearly rate of tuberculosis infection in children in stratified population samples from every district should be monitored to assess reduction, with a goal of at least 5% decrease per year.[29,39] Children around adults with tuberculosis should be screened for infection, and adults around children with tuberculosis need to be screened for disease, so that early intervention can be applied.[40,41]

For more on **National AIDS Control Organisation** see http://www.nacoonline.org/About_NACO/

Panel 1: India's National AIDS Control Programme[42–44]

1986–92

The HIV Task Force of the Indian Council of Medical Research and the AIDS Cell of the Ministry of Health, with funding from the Government of India, laid the foundation for HIV control and systematic monitoring and surveillance of the time trend of HIV infection.

1992–99

The National AIDS Control Organisation (NACO) was launched with a budget of US$100 million, including an $84 million credit from the World Bank. State AIDS Cells were formed in India to help the expansion of blood banks for HIV screening, treatment of sexually transmitted infections, targeted interventions for high-risk groups, and expansion of sentinel surveillance of HIV. Some HIV control projects were implemented in collaboration with the international bilateral agencies.

1999–2006

The second phase of NACO had a budget of $460 million (a credit of $193 million from the World Bank, a similar amount in grants from other international agencies—largest from Department For International Development and USAID, and an allocation of funds by the Government of India). Interventions for HIV prevention in high-risk groups were scaled up through newly established State AIDS Control Societies in collaboration with voluntary non-governmental organisations. Centres for voluntary counselling and testing, and for prevention of parent-to-child transmission of HIV were established, antiretroviral treatment was initiated through the public health-care system, and greater involvement of individuals with HIV/AIDS was attempted. A National Council on AIDS chaired by the Prime Minister was established in 2005 to ensure high priority for HIV control as a broad development challenge requiring intersectoral responses.

2007–12

In the third phase, the National AIDS Control Programme has been given department status by the Ministry of Health, with a budget of $2·5 billion, which includes aid from several international donors and a larger proportion from government. Prevention of HIV infection remains the major focus, receiving 67% of total funds, with 17% assigned for care, support, and treatment of individuals with HIV/AIDS, and the remaining funds for programme management, capacity building, and information management. The objective in this phase is to reverse the HIV epidemic in India. Programme targets for this phase have been set through consultation and there is optimism for success.

HIV/AIDS

The National AIDS Control Programme is the most visible vertical health programme in India because of much global attention and the fear of a rapidly growing HIV epidemic that led to substantial funding (panel 1).[42–44] Control is most successful in Tamil Nadu, where infection was first detected in female sex workers in 1986.[45] The factors for success include early seminal work on the epidemiology of HIV in female sex workers, patients with sexually transmitted infections, pregnant women, and blood donors;[27,46–50] early establishment of several interventions; systematic monitoring of time trends; and substantial political support.[51] These factors were subsequently adopted by the National AIDS Control Programme.

According to UNAIDS, an estimated 5·7 million people had HIV/AIDS in India during 2006.[52] This number was revised to 2·5 million (range 2·0–3·1) in 2007, and the prevalence in adults was estimated to be 0·4% based on the available new population-based data.[53–55] India now has the third largest number of individuals with HIV/AIDS after South Africa and Nigeria.[56] Of the estimated HIV burden in India, women and girls account for 40% and children 4%. The proportion is highest in the southern peninsula states—Andhra Pradesh (21%), Maharashtra (20%), Karnataka (11%), and Tamil Nadu (8%), with a prevalence in adults of 1%, 0·7%, 0·7%, and 0·4%, respectively (figure 2).[53,55,57] The highest prevalence of HIV in adults is in the small northeastern states of Manipur (1·6%) and Nagaland (1·2%).[57] Estimates based on yearly sentinel surveillance and population-based data suggest that the prevalence and burden in adults have stabilised or reduced from 2002 to 2007 in India, mainly because of the reductions in southern states (figure 3).[57,58] However, the concern is that these overall trends might mask the increasing prevalence in some parts of these states and in some northern states with an overall low prevalence,[57] as suggested by an increasing prevalence of HIV/AIDS during the antenatal sentinel surveillance from 2007 to 2008 in the southern state of Andhra Pradesh and some states in other parts of the country (unpublished).

In India, HIV is predominantly transmitted heterosexually, and intravenous drug use is the dominant mode of transmission in the small northeastern states of Nagaland, Manipur, and Mizoram.[43,57,59] Plans to reduce transmission between female sex workers and their clients, including truck drivers, have been the main focus of prevention of HIV transmission since the inception of HIV control programmes in India. As a result of the recognition of the important part played by men having sex with men and by migrant labourers in HIV transmission, more attention is being paid to these groups now.[43,60–62] Prevention of transmission from infected mothers to infants is another important component of prevention of HIV transmission that has been introduced over the past few years.[43] Some interventions have achieved high coverage in India, but most interventions need further scale up for optimum control of infection.[43,63,64] An analysis in Andhra Pradesh suggests that all interventions for HIV prevention cost less than the per person gross domestic product to avert a disability-adjusted life year, indicating that these are quite cost effective.[65] Male circumcision has been shown to be associated with lower prevalence of HIV, but its feasibility and effectiveness in prevention of transmission in India need further investigation.[66,67]

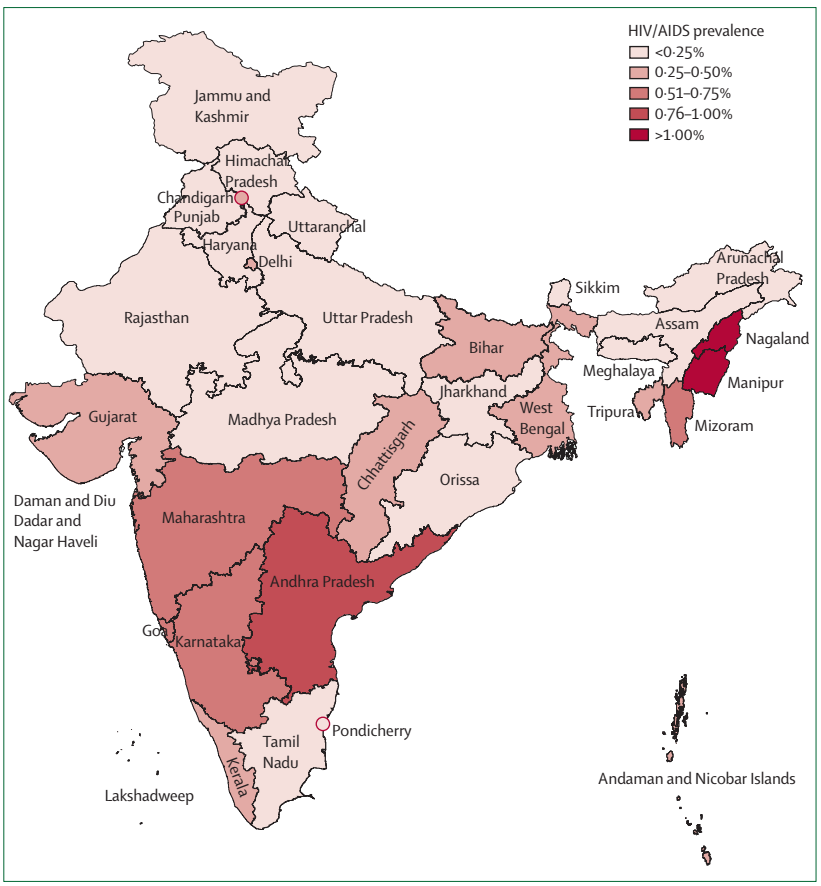

***Figure 2*: Estimated adult HIV/AIDS prevalence in the states of India in 2007**
Adapted from Pandey and colleagues[55] with permission from the Indian Journal of Medical Research, and updated with estimates from the National AIDS Control Organisation.[57]

Tuberculosis, already accounting for the highest disease burden in India that is attributable to one infectious microorganism,[16] has been worsened by HIV.[68] A high rate of resistance to several antituberculosis drugs has been reported in patients with HIV and tuberculosis in India.[69] Early cross referral between services for tuberculosis and HIV is of benefit for more timely detection and treatment of both diseases,[70] but large-scale integration of the control programmes for the two diseases has yet to happen because these programmes have traditionally had a vertical structure. Coordination is also needed with services for other sexually transmitted infections that increase the risk of HIV transmission.[71] Since most patients with sexually transmitted infections and tuberculosis are treated by

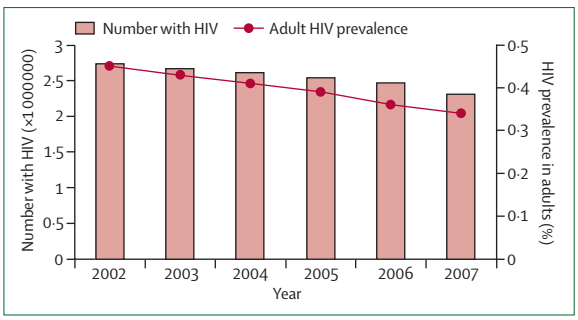

Figure 3: **Estimated burden and adult prevalence of HIV in India**
Data from the National AIDS Control Organisation.[57]

private practitioners, systematic efforts are needed to enhance HIV counselling and testing of these patients.

According to the National AIDS Control Programme, firstline antiretroviral treatment had been provided to 0·3 million people by 2010, a target that was set to be achieved by March, 2012.[43] Although this achievement is good, efforts are still needed to ensure treatment adherence and prevention of drug resistance, and integration with supportive care since treatment of HIV infection is complex.

Substantial achievements in HIV control in India include the establishment of an extensive sentinel surveillance system, engagement with civil society and non-health sectors, efforts at decriminalising sex work and sex between men, and success in prevention of HIV transmission in some states. However, the major challenges that remain for achievement of complete control of HIV in India include decentralised planning to deal with the heterogeneity of HIV epidemiology, capacity building for generation and use of relevant data, and successful integration of HIV control within the health system.

Malaria

For more on **the official number of cases of malaria** see http://nvbdcp.gov.in/malaria3.html

The official number of cases of malaria in 2009 in India was 1·6 million and 1144 deaths were attributable to malaria. However, independent experts estimate a much higher number of cases of malaria in India. Analysis of data from verbal autopsies for 2001–03 from the sample registration system suggested that 125 000–277 000 deaths are caused by malaria per year in India, with the highest rates in the eastern states of Orissa, Chhattisgarh, and Jharkhand, and the northeastern states.[72] The methods used to arrive at this number are being contested. However, the burden of malaria in India is almost certainly more than that suggested by the official data.[73,74] In Madhya Pradesh, with a population of 90 million, an estimated 98 500 spontaneous abortions and 1000 maternal deaths per year were due to malaria.[75] This problem is likely to be big in malaria-prevalent parts of India.[76] The high priority assigned to the control of malaria in India is laudable, but the inability to sustain and increase the rate of control shows the deficiencies in the health system. Malaria predominantly affects rural and poor urban communities in many states where health care is grossly inadequate. Without systematic surveillance, reliable epidemiological data are not generated.

The antimalaria programme has been renamed the National Vector-Borne Disease Control Programme to include interventions against other vector-borne infectious diseases, but outcomes are not monitored. India has malaria zones of high transmission (population 312 million [27%], yearly parasite index greater than one per 1000 population), low transmission (663 million [58%], yearly parasite index less than one per 1000 population), and no transmission (176 million [15%]).[77] In villages in the transmission zone, health workers visit families every fortnight and take blood smears from anyone with fever in the interval (active surveillance). Health-care personnel in public-sector hospitals are expected to report smear-positive malaria to local centres for the National Vector-Borne Diseases Control Programme (passive surveillance). Most of the population avail private-sector medical care, but there is no formal method to gather data for malaria from the private sector. Without high quality surveillance the malaria control effort has little chance of being successful.[78]

The frequency of *Plasmodium vivax* and *Plasmodium falciparum* is changing; figure 4 shows that nationally the frequency of *P falciparum* increased from 14% in 1970 to more than 50% in 2009. Chloroquine resistance in *P falciparum* arose in Assam in 1973.[79] Monodrug-resistant and multidrug-resistant falciparum malaria has spread widely since, establishing new foci. Of 4277 *P falciparum* isolates tested for chloroquine resistance, 1696 (40%) had early or late treatment failure. Resistance to sulfadoxine-pyrimethamine increased from 12% in 1984–92 to 24% in 1997–2007.[80] High frequency of treatment failure was reported in 300 rural primary health centres (92 districts in 20 states) where the combination of artemisinin and sulfadoxine-pyrimethamine was introduced as the firstline treatment for *P falciparum*.[81]

Anopheles culicifacies, the predominant vector for malaria in India, has become resistant to many insecticides; its control remains an enormous challenge and takes up most of the effort to control the spread of malaria. The second major vector for rural transmission of malaria is *Anopheles fluviatilis*. Both species flourish during the monsoon, leading to malaria outbreaks, which have worsened since the 1990s.[82] These vectors invade territories with new economic development—eg, construction sites, irrigated agriculture, and areas with industrialisation—and create malaria ecotypes in arid regions, industrial estates, and along international borders.[83,84] These ecotypes do not respond well to the regimented approach of indoor spraying with clofenotane (dichlorodiphenyltrichloroethane [DDT]), malathion, or a synthetic pyrethroid pesticide for residual effect. In the past 5 years, destruction of the larvae has been attempted

with predatory fishes—*Poecilia reticulata* (guppy) and *Gambusia affinis* (gambusia).[85]

Malaria is now a major problem in urban areas because the vector *Anopheles stephensi* breeds efficiently in fresh water storage containers and in collections of rain water. Even *A culicifacies* has appeared in many towns and cities. The Urban Malaria Scheme, launched in 1970–71, is operative in 131 cities and towns in 19 states with a total of 101 million people.[86]

A review of five districts in five states showed several deficiencies in malaria control, such as surveillance efficiency of less than 50%; adequate indoor residual spraying coverage of only 1·2–17·0%; insecticide-treated bednets coverage of 4·8%; retreatment of 0·9–20·6% bednets; any antimalarial treatment delivered to only 70·6% of people in need of it; 56% coverage with the combination of artemisinin and sulfadoxine-pyrimethamine; difference in the proportion of patients treated in the private sector—eg, 24·4% in Assam and 76·2% in Chennai; and neglect of malaria by obstetric and paediatric services.[87,88] Effective control of malaria needs public health infrastructure, national, and locality-specific evidence-based planning, continuous quality monitoring and supervision, continued training of personnel, and coordination with health care in private and public sectors. Although sufficient funds are available ($440 million in the 11th Five Year Plan [2007–08 to 2011–12]), they are not fully used because of the shortcomings in the health-care system.

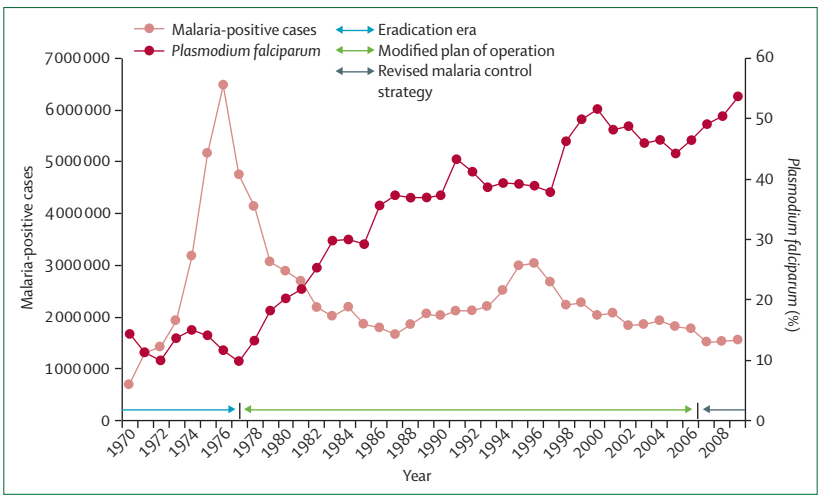

Figure 4: **Strategies of the malaria control programme versus number of malaria cases and proportion of *Plasmodium falciparum* cases in India**
Data from National Vector Borne Disease Control Programme.

Visceral leishmaniasis

Visceral leishmaniasis or kala azar affects mainly individuals who are poor and living in the rural areas of 52 districts in Uttar Pradesh, Bihar, Jharkhand, and West Bengal. There is no known non-human reservoir—eg, dogs do not get infected. Vector sandflies breed in the humus near huts. DDT spraying for malaria control during 1953–64 decimated sandflies and nearly eliminated kala azar.[89] The reservoir of *Leishmania donovani* (including dermal leishmaniasis after kala azar) in human beings allowed parasites to survive, and as sandflies increased kala azar re-emerged. In an epidemic beginning in 1977 in Bihar, 18 389 cases were documented (>100 000 estimated cases); 30% were unresponsive to sodium stilbogluconate, the drug available at the time. Control of the epidemic reduced prevalence, but that was short-lived.

In 1991–92, the epidemic recurred with 59 614 documented cases (>250 000 estimated cases); in some areas, 85% of cases were unresponsive to sodium stilbogluconate.[89] In untreated and unresponsive cases, fatality was nearly certain. Interventions lasted only 3 years. From 2002 to 2007, the prevalence of kala azar increased in India but showed some reduction during 2008–09 (figure 5). In 2003, the Government of India developed an elimination strategy for kala azar, using two rounds of DDT spraying per year; new rapid test kits for diagnosis; distribution of information for public awareness; fortnightly surveillance; and new drugs—amphotericin B and miltefosine.[90,91] India, Bangladesh, and Nepal signed a Memorandum of Understanding in May, 2004, for elimination of kala azar (less than one case per 10 000 population) by 2015.[92,93] The prevalence was 22 per 10 000.[93] Optimism about the feasibility of elimination is not widely shared because of the lack of close collaboration between the vertical control programme for kala azar with health care in private and public sectors.[94]

For more on the **Five Year Plans** see http://planningcommission.nic.in/plans/planrel/fiveyr/welcome.html

Lymphatic filariasis

Infection with nematode parasites *Wuchereria bancrofti* and *Brugia malayi* is endemic among half the population of India. Filariasis caused by *W bancrofti* (99·4% cases) transmitted by *Culex quinquefasciatus* is ubiquitous, but transmission of *B malayi* by *Mansonia annulifera* and *Mansonia uniformis* is geographically highly restricted. India has 40% of the world's burden of filariasis caused by *W bancrofti*.

Filariasis occurs predominantly among people who are poor. Presence of lymphoedema—the long term result of infestation with adult worms, repeated nematode infections, lack of early treatment, and neglect of body care—identifies poor access or quality of health care. Control requires methods to kill mosquitoes and antimicrofilarial chemotherapy, both straightforward in theory but ineffective in practice, except in a few local projects. In 1997, the World Health Assembly resolved to eliminate filariasis as a public health problem by 2020. The National Vector-Borne Diseases Control Programme provides yearly single-dose administration of diethylcarbamazine (6 mg/kg bodyweight) to the entire population at risk, for 5–6 years (equal to the lifespan of adult worms). The elimination programme includes about 250 districts that have endemic filariasis. In 2007, mass

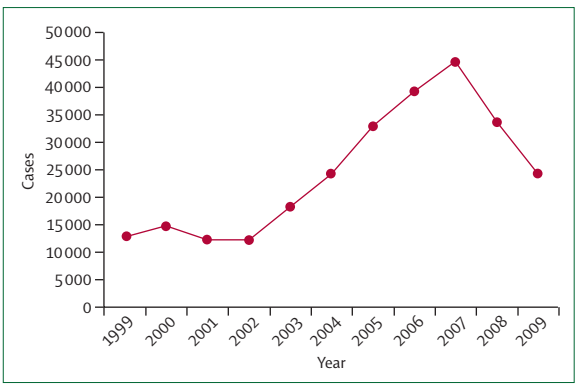

Figure 5: **Kala azar cases in India**
Data from National Vector Borne Disease Control Programme.[90]

drug treatment achieved an average coverage of 82% in 518 million people who were eligible for treatment.[95] Albendazole (400 mg) enhances the antifilarial effect, and causes intestinal deworming.[96] From 2008, the national scale up of the combination treatment was started. Whether India can succeed in eliminating lymphatic filariasis by 2015 or 2020 will only be known with time.[97] The loss of productivity has been estimated at $1 billion per year.[98] In the 11th Five Year Plan, $1·2 million have been allocated for 5 years from 2007–08, 19% of the National Vector-Borne Diseases Control Programme. Other nematodal tissue infections, such as ocular dirofilariasis in northern Kerala, have received little attention from the health system.

Other infectious diseases

Diseases caused by enteric pathogens

Systematic surveillance in Kottayam, in Kerala, showed dysentery (amoebic and bacillary) and typhoid fever to be among the most common diseases reported by physicians.[99] Although widely prevalent,[100] epidemiology of dysenteries has not been investigated.

In two population-based, prevalence studies, the incidence of culture-proven typhoid fever was very high among individuals living in poverty in urban areas.[101,102] In Delhi, the incidence was 2734 per 100 000 children younger than 5 years, 1170 among those aged 5–19 years, and 110 among those aged 20–40 years.[101] In Kolkata, incidence was highest in children aged 5–15 years (493·5 per 100 000 population). In rural Tamil Nadu, cases of typhoid fever were rare, showing much geographic variation in prevalence (unpublished). Paratyphoid fever, particularly type A, is increasingly being recognised.[103,104] In Kolkata, overall yearly incidence of typhoid fever was 140 cases per 100 000 population (mean age 14·7 years) and that of paratyphoid fever was 80 per 100 000 population (mean age 17·1 years).[105] Among 416 cases of imported typhoid fever in the UK (2000–03) with source country identified, 70% were from India and Pakistan;[106] among 208 cases in Switzerland (1993–2004), highest risk was from the Indian subcontinent.[107] Multidrug-resistant strains of *Salmonella typhi* are generally prevalent; fluoroquinolone resistance is emerging and clinicians often give third-generation cephalosporins, increasing treatment cost by about 100 times. Although typhoid Vi vaccine is manufactured in India and popular in private paediatric practice, it is not used in the national vaccination programme.

The Bengal region was the source of all past cholera pandemics. Cholera is endemic in most regions, with recurrent outbreaks, often after the monsoon every year, in many towns as far apart as Vellore (Tamil Nadu) and Ludhiana (Punjab).[108–113] Cholera arises even in the desert regions of Rajasthan (west and northwest of India) from where French travellers were infected.[114] Most metropolitan cities have hospitals specifically for cholera and other infectious diseases. A hospital in Delhi for infectious diseases admitted nearly 10 000 patients with cholera during 2003–05.[115] Of 4251 culture isolates, 96% were O1 and 4% were O139. A third of culture-proven cases were in children younger than 5 years. In Chennai's hospital for infectious diseases, 26 502 patients were assessed in 1980–2000 and 6035 were micro-biologically confirmed, most were O1 and a quarter were O139.[116] The National Institute of Cholera and Enteric Diseases in Kolkata has shown that outbreaks are related to environmental factors.[117] Bivalent-killed cholera vaccine manufactured in India is licensed but not used in the public sector health-care system.

Enterically transmitted hepatitis A and E viruses are widely prevalent. Almost all the population gets infected with hepatitis A virus infection at different ages depending on living conditions and safety of the drinking water.[118] Prevalence of disease, including fulminant hepatitis, increases with age because infection in the young is more frequently subclinical and therefore associated with less disease.[119] Since most individuals are immune, common-source outbreaks are not common. In Kerala, two large outbreaks were documented in 1998 and 2004.[120,121] The outbreak in Kottayam was 1 year after the disease surveillance in districts was replaced with the Integrated Disease Surveillance Project, showing its inability to detect outbreaks or diagnose the cause. Killed and live virus vaccines are used in paediatric practice, but not in the national vaccination programme. India is highly endemic for hepatitis E virus, with many local water-borne outbreaks; eight major epidemics were reported since 1955–56.[122] This virus is also the most common cause of acute sporadic hepatitis in adults, and the most affected age group is 15–40 years. Pregnant women with hepatitis E have bad obstetric and fetal outcomes, and high mortality rates (about 30%),[123,124] except perhaps in south India.[125] Acute hepatitis E in patients with chronic liver disease has poor prognosis.[126,127] Genotype 1 is predominant in India. Although several large vertebrates are infected with hepatitis E virus and hepatitis-E-like viruses, no cross-species transmission has been shown.

Contagious diseases

H2N2 and H3N2 strains were isolated from the pandemics of the Asian influenza in 1957 and Hong Kong influenza in 1968, respectively, at the Pasteur Institute, Coonoor, Tamil Nadu.[128] The National Institute of Virology started influenza surveillance in Pune in 1976, where rainy season outbreaks occurred every year, mostly due to H3N2 and B strains; seasonal H1N1 also appeared in the 1990s.[128] Since the 1980s, several studies have been done to assess the role of viruses in acute respiratory diseases in children in Vellore, Chennai, Lucknow, Kolkata, Delhi, and Pune.[129] Infection with influenza virus was documented in every study, and about 4–15% of nasopharyngeal specimens were positive.[129] India has had several outbreaks of highly pathogenic avian influenza H5N1 in poultry since 2006 in western and northeastern regions, but no infection in people. In 2007, in view of the future risk of pandemic, India established a network of laboratories in Pune, Vellore, Chennai, Kolkata, Lucknow, Wardha, and Delhi for virus strain surveillance; however, results are not yet available in the public domain. India does not have systematic surveillance or vaccination for influenza, and pandemic preparedness is fragile. The frequency of secondary bacterial pneumonia is not known, but pneumococcal pneumonias are frequent in clinical practice, and are diagnosed and treated empirically; quantitative data are not available. The handling of the pandemic 2009 H1N1 virus in India is described briefly in panel 2.

Not generally known, varicella affects a very wide age range, from childhood to the fourth and fifth decades (median age 13 years), unlike in the western countries (<5 years).[131,132] Varicella poses a risk to health-care workers and through them to patients with cancers who are immunosuppressed.[132] Vaccination of students and staff in medical institutions is recommended to prevent nosocomial varicella.[133]

Vector-borne infectious diseases

Japanese encephalitis is the most common viral encephalitis in children, prevalent in almost all parts of India except the northwest. Since vaccination has been introduced in 62 endemic districts though the Universal Immunisation Programme, the hope is that Japanese encephalitis will no longer cause outbreaks.

Dengue viruses (types 1–4) were first isolated from febrile patients and *Aedes aegypti* mosquitos during the 1960s in Vellore, but dengue haemorrhagic fever has been around only since 1987. Once confined to a few towns in the south, now dengue haemorrhagic fever occurs throughout the country. The first dengue haemorrhagic fever outbreak was seen in Perambur (suburb of Chennai) in 1987 (virologically confirmed in Vellore, unpublished), when outbreaks also occurred in Sri Lanka and the Maldives. When a large outbreak of dengue haemorrhagic fever occurred in Delhi in 1996, the media and the government took note. More than 16 000 estimated cases of dengue fever, and an unknown number of cases of dengue haemorrhagic fever resulted in more than 550 reported deaths.[134] Since then outbreaks of dengue haemorrhagic fever are accepted as inevitable. This neglect was followed by a massive epidemic of fever caused by Chikungunya virus in 2005–07, transmitted by *A aegypti* and *Aedes albopictus*, which is widespead.[135] The commonly quoted number of 1·39 million is only a fraction of the total because there is no case-based functional disease-surveillance for capturing data from medical establishments.[136] The epidemic sequentially affected, during many months, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala, Gujarat, and Rajasthan. Large numbers of people died in Kerala and Gujarat, but data were not gathered in the absence of systematic studies.[137] The previous epidemic of Chikungunya virus fever was in 1964–66, extending from West Bengal to Tamil Nadu, and the virus was isolated in Kolkata and Vellore.[135] The virus was transmitted exclusively by *A aegypti*; hence, the western coastal states had been spared, but were severely affected in the present epidemic probably because the entire population was immunity naive. The lack of preparedness (to take preventive measures or even

Panel 2: 2009 influenza H1N1 pandemic in India

India established systematic screening, starting in mid-April 2009, of all individuals arriving from outside the country for fever and respiratory symptoms; tested each person with symptoms for infection with PCR and admitted individuals with an infection to an isolation facility in a hospital; and treated them with oseltamivir. On May 16, the first infection was detected, and by this date 65 individuals had been tested among the 615 000 who were screened. By Sept 26, 6 412 432 passengers had been screened; 225 doctors and 172 paramedics were employed for this purpose. We believe this huge effort was not necessary. Also by this date, respiratory swab specimens from 407 789 urban dwellers with influenza-like illness had been tested for pandemic H1N1 infection and 9694 were positive; 298 (3%) of these individuals died. Analysis of the cause of death—ie, secondary bacterial pneumonia, comorbidities, or primary viral pneumonia—is not available, but the Ministry of Health and Family Welfare publishes daily statistics. Initially all tests, irrespective of the geographic locations of individuals with influenza-like illness, were done in just two laboratories; because of the large number of specimens, a few more laboratories in the public and private sectors were allowed to do tests. Thus, the pandemic has provided a focus on the paucity of laboratories and the neglect of endemic and seasonal influenza. In this process of widening the scope of testing, still only done in the urban population, the distinction between evidence gathering for epidemiology or public health versus cause-specific diagnosis for health care was not clarified.[130]

For the **Ministry of Health and Family Welfare daily statistics** see http:\\www.pib.nic.in/h1n1/h1n1.asp

evidence-based diagnosis in health care) is an indication of how the country remains unprepared for yellow fever.

Pathogens in blood and body fluids

Pioneering work done in India in 1971–72 showed a very high risk of post-transfusion hepatitis B, leading to a revision of safety standards for transfusions.[138] These revised standards were reinforced with the detection of HIV in blood from donors.[46,139] Although the magnitude of diseases due to infection with the hepatitis B virus is likely to be huge, it is not known because there is no surveillance of chronic hepatitis, cirrhosis, and hepatocellular carcinoma. The prevalence of hepatitis virus surface antigen in blood varies from 0·1% to 11·7%, with the most common prevalence of 2–8% and a few population groups with more than 15%. About 15–40% of cases of acute hepatitis, 11–27% with acute liver failure, 35–60% with chronic liver diseases, and 60–80% with hepatocellular carcinoma are caused by hepatitis B virus.[122] In India, about 40–50 million people, the second largest number after China, are estimated to be carriers. Without intervention, an estimated 9 million individuals in a birth cohort have a lifetime probability of infection, and more than 1·5 million will develop chronic infection and about 200 000 will die as a result. Mother-to-infant transmission and progression to hepatocellular carcinoma are less frequent in India than in east Asia.[140,141] However, hepatitis B virus is the most common cause of hepatocellular carcinoma.[142] In addition to the horizontal transmission through intrafamilial close contact and through sexual contact, injection-related iatrogenic transmission seems to be rampant in some parts of India.[143] A large outbreak of hepatitis B occurred in Modasa in Gujarat during the first quarter of 2009, resulting in more than 70 deaths; transmission was through contaminated injection equipment.[7] Its detection and investigation were delayed in the absence of disease surveillance or cause-of-death monitoring. A hepatitis B virus vaccine was approved for inclusion in the national vaccination programme in 2003–04, but its nationwide implementation continues to be delayed.

Infection with hepatitis C virus has a population prevalence of about 1%.[122,144] Unsafe injection practices are prevalent in many places, as shown by the prevalence of 55% infection among paid blood donors in Gujarat.[122,144] Although hepatitis C virus is a rare cause, if any, of acute hepatitis, about 60% of individuals infected remain carriers; 14–16% of individuals with chronic liver disease and 14–20% of those with hepatocellular carcinoma have chronic infection.[122,144] In the 1990s, many health-care institutions voluntarily started screening blood for transfusions for the presence of antibodies to hepatitis C virus. In a study done in Kolkata, the frequency of infection among recipients of several transfusions was 16% before 1995 and 6% since 1995, and 2% among controls.[143] Screening was made mandatory in 2002.[122] Genotype 3 is prevalent in all regions except the south, where genotype 1 is prevalent. Genotype 4 is rare in the south.[122]

All herpes viruses are prevalent in India.[132] Cytomegalovirus infection is acquired early in life, and fetal or neonatal infection with clinical disease is very rare because of passive immunity.[145] However, reactivation disease is common in renal transplant recipients taking immunosuppressive drugs. Genital infection with herpes virus 2 is perhaps the most common sexually transmitted infectious disease.[146] All other universally prevalent sexually transmitted infectious diseases are widely distributed, but reliable quantitative epidemiological data are not available.

In India, cancer of the cervix, caused by chronic infection with human papilloma virus (HPV), is probably the most common cancer in women,[147] with an estimated 132 000 new cases and 72 000 deaths every year. These estimates are from sentinel sites with cancer registries. The ten most frequent HPV serotypes arising in cervical cancer are 16 (65%), 18 (15%), 45 (6%), 33 (6%), 35 (5%), 58 (4%), 59 (2%), 56 (2%), 31 (2%), and 51 (1%). Infection with HPV types 16 and 18 accounted for 79% of overall infection, with some geographic variations in the north (88%) and south (77%).[147] HPV vaccines containing types 16 and 18 have the potential to prevent more than 75% of cases of cervical cancer. The detection of HPV infection (with PCR) in the cervix was more sensitive for the prediction of the risk of cancer than was cytological or visual screening with acetic acid.[148]

Neglected zoonotic infectious diseases

Panel 3 shows a list of highly prevalent, but neglected, zoonotic infectious diseases. A few zoonoses are geographically focal because of specific ecological factors. Kyasanur Forest disease (tick-transmitted flavivirus) occurs in Shimoga in Karnataka, affecting only those who gather forest produce. Increase in the number of deaths in monkeys indicates an increase in the number of infected ticks. Plague (*Yersinia pestis*) is enzootic in sylvatic rodents in the foothills of the Himalayas and rarely causes human disease. Only two outbreaks of Nipah virus have been reported, in Siliguri (2001) and Nadia (2007) in West Bengal.[163,164] Results of studies in Vellore and Cochin have provided antibody evidence of hantavirus infection.[165] The prototype virus (Thottapalayam virus) was isolated in Vellore from *Suncus murinus*.

Other infectious diseases

Although the infectious diseases discussed are not exhaustive, they show the size of the problem and neglect of public health. Additional examples of underappreciated diseases include environmental (saprophyte) organisms causing disease—eg, *Burkholderia pseudomallei*, mycobacteria (non-tuberculous), *Cryptococcus neoformans*, *Histoplasma capsulatum*, aspergillus, and candida. Melioidosis is widely prevalent, but grossly underdiagnosed because it requires careful microbiological

investigation.[149,166] Poor sanitation results in intestinal protozoan and worm infestations. Pulmonary paragonimiasis, a disease that mimics pulmonary tuberculosis, was discovered in several northeastern states since 1982 and is caused by *Paragonimus westermani* and *Paragonimus heterotremus*, which are parasites of crabs and crayfish.[167,168] Melioidosis and paragonimiasis are often mistaken for treatment-resistant tuberculosis. RNTCP does not have a process by which diagnostic tests can be done for diseases other than tuberculosis.

Way forward

Need for an agenda

India is a textbook for anyone wishing to study infectious diseases. What do we draw attention to? The nearest primary health centre for someone who is sick is likely to be 5 km away, and the medical officer there is unlikely to be familiar with the wide range of infectious diseases that are prevalent in the region and probably will not have access to a microbiology laboratory. The vertical approach to disease surveillance has been ineffective in providing the comprehensive evidence-base needed for decision making. Regular periodic bulletins are not freely available to the population (panel 4). The referral process to a secondary-care hospital is not respected, so patients might as well join the queue for primary care. Again access to a microbiology laboratory is unlikely, but the specialist in internal medicine might admit individuals who are seriously ill to the hospital, or give prescriptions for reasonably appropriate antimicrobial drugs (for one or more pathogens), which have to be purchased by the patient. Therefore, the patient might decide that staying at home and letting nature take care of itself is simpler because the probability of preventing death or morbidity might not be much different unless the diagnosis was correct, but the risk is the patient's either way. Even though life and health are human rights, there is little accountability for the quality or equity in health care in India or for prevention and control of locally prevalent infectious diseases.

Many infectious diseases discussed in this report could be prevented in individuals, and controlled in the community with a public health system and adequately trained public health personnel. Disease prevention reduces hospital admission and outpatient visits, thus allowing more room for the care of unpreventable diseases. It is also a major factor in poverty alleviation through reduction of out-of-pocket spending and improved work efficiency. Thus our list of infectious diseases draws attention to the urgent need to develop an agenda to systematically control them.

The vertical model for disease control has shown some success, but has serious limitations, some of which might be overcome through linking of all vertical programmes in an integrated model. The implementation and monitoring of vertical programmes should be integrated in the districts; this process would require an empowered team leader for supervision. The district health officer who is mandated to be the representative of the government for health in the districts should be equipped to serve effectively in this role. Unless surveillance captures real-time cases of disease diagnosed by doctors in public and private sectors of health care, it will not serve the purpose of signal generation for prompt public health action.[9,10] The lessons learnt from the control of infectious diseases should also be used to develop integrated disease control efforts that include non-infectious diseases,

Panel 3: Neglected zoonoses of major public health importance in India

Leptospirosis
Very widely prevalent; causes outbreaks after heavy rains and waterlogging.[149,150] Two unusual presentations of disease are haemorrhagic pneumonia and uveitis.[151,152]

Rabies
More than 20 000 deaths per year as a result of inadequate care after a dog bite.[153] Sylvatic reservoir is unknown, but rabid jackals (*Canis aureus*) enter human habitats and infect dogs.[9]

Brucellosis
Microbiologists detected infection in many centres; epidemiology has not been investigated. The habit of boiling milk before consumption is protective against infection.[154]

Typhus and rickettsioses
Scrub typhus is increasingly recognised widely; case fatality of 10–15% is due to clinical misdiagnosis or delayed treatment.[155,156] Spotted fevers are also common, but benign.[157–159]

Anthrax
Animal anthrax is widely prevalent, and vaccination is practised. Small focal outbreaks in people occur frequently, but public awareness is very low.[160]

Tetanus
Although tetanus in neonates has been greatly reduced with systematic antenatal vaccination, tetanus in adults is under-recognised as a problem. Disease frequency seems to have decreased substantially.

Cysticercosis
Individuals who eat pork and get tape worm infestation excrete the eggs in faeces. They might also develop cysticercosis due to autoinoculation. Because of faecal contamination of water and food, even vegetarians may ingest tape worm eggs and develop cysticercosis. Larvae (cysticerci) lodged in eye or brain cause disease. About one in 1000 adults are estimated to have epilepsy that is attributable to cerebral cysticercosis[161] in regions that were investigated.

Hydatid disease
Echinococcosis (granulosus) is widely prevalent in India. When hydatid cysts develop in lungs or liver, serious disease ensues.[162]

Panel 4: Gaps and opportunities in surveillance systems for infectious diseases in India

Two general mechanisms are used for the surveillance of infectious diseases: the Integrated Disease Surveillance Project (IDSP) and the vertical disease control programmes. IDSP, launched in India in November, 2004, has been implemented to varying extents in different states.

IDSP is a decentralised, state-based surveillance system for a few diseases that are of public health importance.[169] Originally conceptualised for a few reporting units per district, IDSP was expanded with the intention of involving the entire public health reporting system in each district. Involvement of the private sector has been attempted only in some states, leading to wide gaps in ownership, resources, and reporting quality. The programme has not been successfully initiated in most districts. Surveillance still remains restricted to periodic summaries or events mostly detected through informal sources including media. The reporting format is cumbersome. Too-frequent changes of functionaries, reporting formats, and method of reporting have adversely affected the performance efficiency of the programme.

IDSP has not achieved effective integration of interventions for disease control. Efforts were made to implement convergence of reporting. District Malaria Officers were instructed to share their reports with and participate in IDSP activities in the district. Some states have an improved convergence because the District Malaria Officer is the IDSP-designated District Surveillance Officer. Also, the forms for reporting malaria were changed thoroughly to match the IDSP reporting system.[170] Results have, however, not been as expected and large gaps continue to exist. Detection and reporting of outbreaks of common infectious diseases have improved in some states. A feedback mechanism of bulletins for decision makers at state and district levels has been attempted as part of the programme.

Vertical programmes like National Vector Borne Diseases Control Programme and National AIDS Control Programme have developed a good network of facilities across districts in the country, including sentinel surveillance sites. These tend to encourage further verticalisation of vertical programmes—such as sentinel networks for Japanese encephalitis guidelines for surveillance of acute encephalitis syndrome with special reference to Japanese encephalitis,[171] dengue, and lymphatic filariasis have been laid down separately, based on their distribution. The Revised National Tuberculosis Control Programme also has its own data gathering system, reported through a dedicated website.

IDSP has institutionalised a platform for establishing a surveillance system for important infectious diseases. It offers an opportunity for convergence of resources and databases for improved planning and effective control efforts for infectious diseases but substantial benefits from this system are yet to be realised. The future need to link data gathering for major non-infectious diseases is also envisaged in IDSP.

through a broad-based public health approach, locally coordinated with the health-care system.

How did India miss the elephant in the room? The design of the health system after independence had a serious flaw of lacking a public health infrastructure, which was crucial even from the start to identify the urgently needed public health functions. This flaw was not necessarily the legacy of colonial rule since Sri Lanka took in the notion of public health, which India did not. The colonial government commissioned an exhaustive study into the needs of health-related services, resulting in a three-volume Bhore Committee Report in 1946.[172] In this report, the recommendation was integration of public health and health care through a network of primary health units, which were actually implemented by India after independence. Jawaharlal Nehru's emphasis on science and technology was shown in a biomedical model of health and disease, and the sociocultural and poverty-associated determinants of diseases were blurred according to medical experts. Close interactions between state-controlled health care and centre-controlled public health seem to have been intended in the idea of integration, but not established in the centre-state sharing of responsibilities that were written in the constitution. A committee chaired by Arcot Lakshmanaswami Mudaliar after independence noted this deficiency and recommended streamlining public health, which resulted in Tamil Nadu alone continuing a Department of Public Health. The dominant health-care leaders advising the Government of India apparently did not see the need to establish a public health subsystem at the centre.

Independent India listened to the expert advice from international agencies, in many cases without the parallel autonomous inputs that were needed for proper contextualisation and long-term success. In 1978, the Alma Ata Declaration of health for all through primary health care seemed attractive since India already had primary health units. These units were mistakenly thought to be able to provide primary health care, losing in the process the essential components of decentralised public health interventions and quality health care.

The same year, India adopted the Expanded Programme on Immunisation, which was assigned to primary health centres for implementation. Addition of maternal tetanus vaccination from the Expanded Programme on Immunisation to the already functioning family planning services was easy. Thus, elementary interventions during pregnancy and childhood became the surrogate for primary health care. WHO and UNICEF emphasised reduction of child mortality rate for which the health of the mother and children was crucial. Revised programmes came in succession: Mother and Child Health, Growth Monitoring, Oral Rehydration, Breast Feeding and Immunisation, Safe Motherhood, Reproductive Health and Child Health, and Integrated Management of Childhood Infections. Retraining of staff and reorganisation of implementation and documentation required energy and detracted attention from all other public health issues. The general perception is that maternal and child health programmes are the priority in the management of rural health, whether they are called public health, preventive medicine, or primary health care. The consequent neglect of basic health care in rural populations was only recently diagnosed, with attempts to remedy it through the National Rural Health Mission.

Also in 1978, selective primary health care for targeted control of a few prioritised diseases was promoted by the World Bank. India already had longstanding programmes to control tuberculosis, malaria, leprosy, cholera, and

typhoid fever. The programmes on the international agenda (tuberculosis, malaria, and leprosy) were easily revised and the impression was created that the health system was now robust enough to withstand all important infectious diseases. However, in this process cholera, typhoid fever and many other infectious diseases were left without control efforts. Towards the last quarter of the 20th century the common misconception was that India was succeeding in the control of infectious diseases through use of vaccines and antimicrobial drugs. New and resurgent infectious diseases were thought to be a part of a global trend.

The medical profession and professional associations do not appreciate public health for various reasons. In medical colleges, public health has been taught as social medicine, preventive medicine, community medicine, and eventually community health. The overemphasis on biomedical interventions overshadowed the contribution of social determinants of infectious diseases. Epidemiology and health economics became research disciplines that were not adequately linked with the health system in central or state governments. These reasons were the root causes of the deficiencies in the public health system in India, which has resulted in a long list of infectious diseases that are inadequately controlled.

Creation of public health infrastructure

India, as an emerging world economic leader, needs to rescue its reputation as a country that provides its people freedom from the many endemic and outbreak-prone infectious diseases that impoverish families through loss of income and out-of-pocket spending on health care. Families often have to borrow, or occasionally liquidise their capital assets—eg, selling cattle, land, or even their homes. Prevention and control of infectious diseases require a public health infrastructure, a cadre structure, professional leadership, trained human resources, and adequate economic investment.[1,2]

Incrementally adding new programmes will not solve the fundamental systemic deficiency. Even the innovative, highly visible, and generally successful Integrated Child Development Service Programme (for nutrition, missing in primary health care), National Rural Health Mission, and proposed National Urban Health Mission have severe limitations in terms of public health functions. Although all such programmes are good in themselves, none of them can individually or collectively fill the void of an overarching public health infrastructure.

The health system in India has to be modified with a major focus on public health in addition to the current focus predominantly on medical care. Instead of incremental changes, a transformation is essential. The current national government came to power with the people's mandate for stability, continuity, and socio-economic development, and promised in its election manifesto health security for all. Now is therefore the best time for an overhaul of the health system.

The Calcutta Declaration on Public Health made a plea to the governments in 2000 to accept the discipline of public health as an essential requirement and to create career structures nationally, and in states and districts,[3] but this plea has not been acted on. Since the district is the logical unit for civil administration, so should it be made the unit for integration of the activities of medical care and public health. In 1994, in response to an outbreak of suspected pneumonic plague in Surat city in western India, the Government of India appointed the Technical Advisory Committee on Plague, which identified the urgent national need for trained epidemiologists to respond to signals gathered through disease surveillance in districts and that has not happened.[173] A Department of Public Health should be created that is on a par with other existing departments, with a government secretary selected from technically qualified individuals, as was the case for the Department of Health Research, which was created in 2008.

To cater for the expected need for trained public health officers in districts, states, and the centre, a national public health service could be designed that is similar to the Indian civil services, which include administrative, police, and foreign services. Side by side, the relations and budget-sharing between states and the centre should also be re-examined for adequacy and functional efficiency. These prescriptions come from our own assessment, but we do not have the necessary skills to design a specific model, for which wider consultations are obviously essential. What we have provided is more of a product description rather than specification for construction. A change is imperative as discussed in another report in this *Lancet* Series.[174] A suitable think tank might be created by the Government of India, such as a National Commission on Healthcare and Public Health, to help make this need for transformation a reality.[175]

There is an alarming and rapidly rising trend in the burden of and mortality due to lifestyle diseases (non-communicable, metabolic, or related to urbanisation) in India as discussed by Patel and colleagues[176] in this Series. The public health system that learns from the control of single-pathogen infectious diseases should be able to address the control of lifestyle diseases that often have multifactorial causes. If control of infectious diseases is the primary school of public health, control of lifestyle diseases is the high school to which we have to progress in the shortest possible time.

Contributors

TJJ and LD led the drafting of the report and revisions in response to reviewers' comments; VPS and MK contributed to parts of the report. All authors have approved the final version of the report.

Conflicts of interest

We declare that we have no conflicts of interest.

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