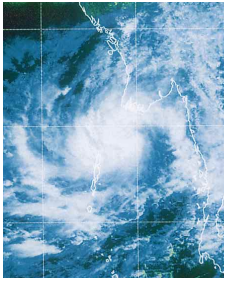


CHAPTER XVII

MEDICAL SCIENCES

Just prior to India's Independence, the then Government recognized that both the health care delivery services and medical education facilities, specially the postgraduate education were woefully inadequate for the needs of the country. Therefore, a Health Survey and Development Committee was appointed under the chairmanship of Sir Joseph Bhore in 1942-43. The Committee submitted its report in 1946. Among its many recommendations were two at the either end of the Health & Medical Education system, i.e. the establishment of Primary Health Centres (PHCs) and the creation of an apex institute for postgraduate education and research. It was, however, due to active efforts of the newly installed National Government that the first PHCs were established in 1952 and the All India Institute of Medical Sciences (AIIMS) in 1956. The existing district and provincial hospitals were progressively upgraded and the number of medical colleges increased. Selected bright young medical graduates were sent abroad to centres of excellence for training in the newly emerging disciplines like cardio-thoracic, plastic, neurosurgery and biomedical sciences. A number of young persons went on their own initiative. Back home they enucleated these specialities thus paving the way for achieving self-sufficiency in postgraduate teaching and training and in turn strengthening the research base.

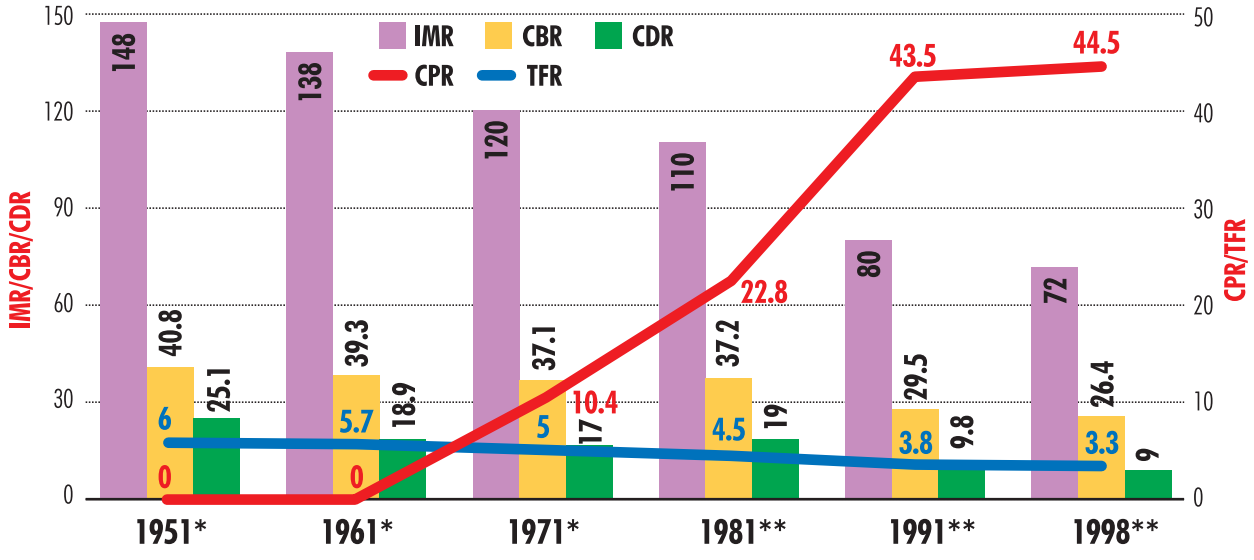
SUKHAM SAMAGRAM VIJNANE VIMALE ĊA PRITISHTHITAM.

ALL HAPPINESS IS ROOTED IN GOOD SCIENCE.

ĊARAKA

Health Care Delivery: At the time India won Independence, modern medical facilities were available mostly in our metropolitan and capital cities. District hospitals and in some places *taluk* hospitals existed but these were generally ill-equipped and did not provide any specialized services. The country is now served with a vast network of some 120,000 rural subcentres manned by one or two paramedical workers, approximately 19,000 PHCs, each with a staff of 15 paramedical workers and one or two medical officers, 3,500 community health centres having some speciality services and 30 in-patient beds. Each district has its own district hospital with a number of specialities -- medicine, surgery, orthopaedics, ENT, obstetrics and gynaecology, usually with over 100 beds with routine diagnostic laboratories. The country has over 160 recognized medical colleges and some in the private sector; new ones are being opened up. In addition there are a number of national institutes and speciality centres distributed around the country, staffed by specialists in all conceivable disciplines and equipped with the latest state of the art facilities.

CHANGE IN FERTILITY AND MORTALITY



How Has the Country Benefitted by These Developments ?

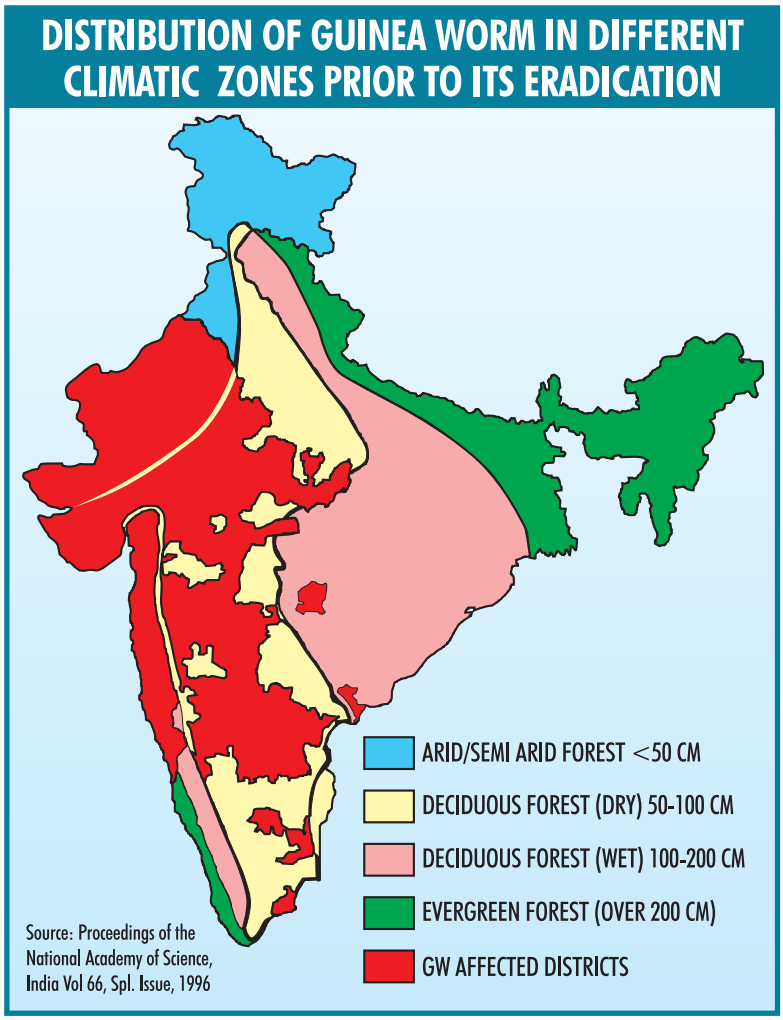
Undoubtedly, the answer is that these developments have resulted in a significant improvement in our health indices. Life expectancy at birth which was around 30 years in 1947, is already 60+. The infant mortality has come down from 140 to 72 per 1,000 live births and maternal mortality to 4.6 per thousand. No doubt, these are still unacceptably high for any civilized society but trends are towards continuous improvement.

As a result of expanded immunization programme, there has been a progressive reduction in several infectious diseases. Smallpox has been eradicated, indications are that poliomyelitis may also be eliminated in near future. Already its incidence has been reduced to very low levels. Dracunculosis or guinea worm infestation, a curse in some parts of the country, has been wiped out. Since the introduction of oral rehydration programme, the mortality from childhood diarrhoeas and cholera has come down. There has been a perceptible reduction in the incidence of leprosy. Except for a minor outbreak, between August and October 1994 (affecting a limited geographical area and promptly brought under control), plague had virtually disappeared from the country. On the other hand malaria, kala-azar and some other vector-borne diseases which were fairly well controlled have once again become a matter of concern. Tuberculosis

Health Indices

	1951	1961	1981	1991	1995	2000
Crude Birth rate (per thousand)	40.8	39.3	37.2	29.5	28.5	26
Crude Death rate (per thousand)	25.1	18.9	5.0	9.8	9.2	9.0#
Infant Mortality Rate	148	138	110	80	74	72*
Life Expectancy at Birth	32	41.3	56.0	61.2	-	60+
Total Fertility Rate	6	5.7	4.50	3.80	3.40	3.3
Couple Protection Rate	-	-	22.8	43.5	-	45.0

#In Kerala death rate is 6, Tamil Nadu and Karnataka 8, Andhra Pradesh 8.4.
*In Kerala the infant mortality rate is already down to 16 per 1,000. In Punjab, Maharashtra and Tamil Nadu this is around 50.



Guinea worm infection. (Source: Proceedings of National Academy of Sciences, India, 1966)

continues to affect two million persons causing 500,000 deaths every year. The situation is likely to become worse with the emergence of HIV / AIDS infection.

Extensive community studies revealed that approximately 170 million people were living in iodine deficient regions in the country. There was an alarming incidence of cretinism (3-5%), feeble mindedness (IQ 69 or below in 29%) and hearing deficiency (20%). With the introduction of universal iodination programme since 1986, there has been a perceptible reduction in iodine deficiency diseases, specially the severe variety of neonatal hypothyroidism with mental retardation and cretinism in badly affected regions of the country. Vitamin A supplementation programme has likewise started to show its beneficial effects for prevention of blindness. One could enumerate several such success stories. Yet the very fact that their root causes, poverty, lack of supply of safe drinking water, malnutrition coupled with unabated rise in population, high incidence of illiteracy and lack of adequate financial resources continue to bedevil the efforts, for which there are no S&T quick-fixes.

Similarly, if progress is to be measured by the proliferation of curative services, both in public and private sectors, India has made significant strides. Today we can proudly say that while at the time of our Independence we had no neurologist or neurosurgeon, no cardiologist or cardiac surgeon, only one cancer hospital worth the name, no specialized research-cum-service institute in any field of medical science, we now have all the facilities to train all our specialists in the country. A limited number of doctors from the neighbouring countries are also being trained. This facility could certainly be augmented if required. It can be stated without risk of contradiction that no patient needs to go abroad for any treatment or investigation. Renal transplant, cardiac transplant, liver transplant and bone marrow transplant have been successfully performed in India. Several centres can boast of results comparable to the best, be it for cancer, cardiac surgery or brain surgery. These services

are also provided to patients from the neighbouring countries. No doubt there is still a growing need for expanding these services quantitatively and geographically to make them available in every part of the country.

Medical Education and Research

In 1947, the country had only 16 medical colleges. While postgraduate speciality courses existed in most of these, unless one had a diploma (FRCS, MRCP, DCH, DO, DTM&H) from the Royal Colleges in the United Kingdom, a person was not considered adequately qualified for appointment as a specialist. Soon after Independence, there was a rapid growth of medical colleges all over the country. Today there are more than 160 such institutions with an annual enrolment of 16,000 students. To meet the growing needs of teachers for these colleges, as well as to create an environment for high-quality research, in 1956, AIIMS was established at New Delhi, by an act of the Parliament. Subsequently several such institutes like Post -Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, The National Institute of Neurosciences and Mental Health (NIMHANS), Bangalore, and Sri Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, were started.

A STRONG S&T BASE IS CRUCIAL FOR SOLVING HEALTH PROBLEMS FACED BY A COUNTRY.

Compared to the scenario fifty years ago, medical research has certainly progressed. There are a number of institutes created by the Indian Council of Medical Research (ICMR), Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT) and other agencies which are actively involved in biomedical research. Many of these have set up centres to address problems of specific diseases such as the Malaria Research Centre, Delhi; the Cholera Research Centre, Kolkata; Tuberculosis Research Centre, Chennai; Vector Control Research Centre, Pondicheery; National AIDS Research Centre, Pune; Enterovirus Research Centre, Mumbai; and Leprosy Research Centre, Agra. Others are more broad-based like the Virus Research Centre at Pune, Institute for Research in Reproduction and Institute of Immuno-haematology at Mumbai, National Institute of Nutrition, Hyderabad and National Institute for Communicable Diseases, New Delhi. In addition to the ICMR, several scientific agencies have created research centres in specialized fields related to medical sciences like the National Institute of Immunology, New Delhi, National Centre for Cell Sciences, Pune; Centre for DNA Fingerprinting and Diagnostics, Hyderabad; National Brain Research Centre, Manesar; Functional Genomic Research Unit at Centre for Biochemical Technology, Delhi by DBT. Like-wise the Central Drug Research Institute, Lucknow; Indian Institute of Chemical Biology, Kolkata; Indian Institute of Chemical Technology and Centre for Cellular and Molecular Biology, Hyderabad; Industrial Toxicology Research Centre (ITRC), Lucknow; and Central Institute of Medicinal and Aromatic Plants, Lucknow; were established by the CSIR and Radio-pharmaceutical Centre and Cancer Research Centre by the Atomic Energy Commission. Thus a network of centres provide the infrastructure for medical research in the country. In recent years a few research centres have been established by major pharmaceutical industries and private organizations. Research is also being carried out at medical colleges and major hospitals in the country.

Even prior to mentioning some of the outstanding research findings of the Indian biomedical fraternity, it is important to explain the need for carrying out research. It has often been

stated that developing countries should not waste their limited resources on research since application of the already existing knowledge can solve many of their health problems. Experience has taught that whereas a strong S&T base is essential for survival of any country in this competitive world, it is even more crucial for solving the health problems predominantly faced by a country. Many diseases prevalent in the developing countries are of little interest to those in the developed world. World wide investment for research on health has been estimated to be about 30 billion dollars but only 5 per cent (1.6 billion) is devoted to the health problems of developing countries, which account for 93 per cent of the global burden of preventable mortality (measured in years of potential life loss). Out of $ 1.6 billion spent on developing country-oriented research 42% originated in the developing countries. It is now well established that the same disease prevalent in different parts of the world may not manifest identical problems, thus requiring locale-specific studies. Different ethnic populations, different genetic make up, varying socio-economic conditions or ecological environment modify the manifestations and therapeutic responses of a disease which prevent application of knowledge generated elsewhere to effectively deal with it. At the same time without indigenous competence in S&T, it is not possible to identify and utilize one's potential strengths taking advantage of the indigenous heritage and resources.

Community Based Research

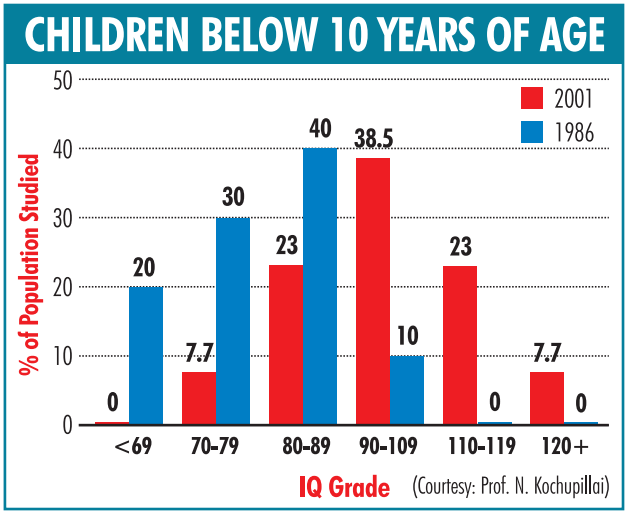
A number of important contributions of national and international significance have been made in recent years in every sphere of biomedical research. It is not possible to present a comprehensive account but a few are listed here to illustrate the above premises and to provide an idea of the range of activity. Thus amongst the community based studies one could unhesitatingly mention BCG trial, the oral poliovaccine studies, the iodine deficiency syndromes, the indigenously developed leprosy vaccine trials or the bio-environmental approaches to control malaria, epidemiological studies on cholera, malaria, filaria, leprosy, tuberculosis, cataract, coronary heart disease, stroke and cancer.

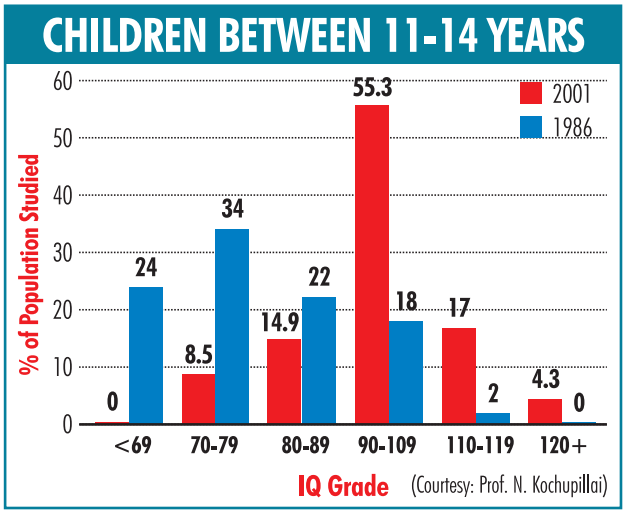
BCG Vaccine Trial: BCG had been universally acclaimed as the most effective vaccine available against tuberculosis. It was therefore accepted as a component of the Tuberculosis Control Programme from its very inception. However, doubts were soon raised about its efficacy in Indian population. The Tuberculosis Research Centre, Chennai, underlook a controlled field study in 1963. After an extensive carefully planned and executed study, it was established that BCG offered, i) low levels of protection in those aged 0-14 years, ii) no protection against the development of adult type bacillary tuberculosis, and iii) 20% protection against leprosy.

Oral Polio Vaccine Trial: WHO recommended three dose oral polio vaccine regime as a component of neonatal immunization programme. Unfortunately a number of children so vaccinated developed paralytic polio. Initially it was blamed on failure of cold chain. However, carefully carried out studies at Vellore and New Delhi unequivocally established the inadequacy of this regimen in India resulting in a radical change in the national programme which now seems to be producing desirable results.

Iodine Deficiency Studies: The prevalence of

Paralytic poliomyelitis due to wild poliovirus infection has declined by more than 85% in most parts of India. More than 1,000 cases of poliomyelitis were annually reported from the city of Mumbai in the mid-1980s, in 1999, only 18 virologically proven poliomyelitis cases were reported from the entire state of Maharashtra of which 3 were from Mumbai. It is inspiring to note that Orissa has emerged as a polio-free state in the year 1999.





thyroid goitre in several regions of the country was well-known, however, its real gravity and etiopathogenesis were only brought to light with the utilization of the latest techniques of chromatography and radioimmunoassay by a team of researchers from AIIMS among some others. It was not the clinically obvious goitre but the incidence of cretinism, mental retardation and deaf-mutism that forced the Government to introduce universal iodination of the common salt as an imporant component of the National Iodine Deficiency Control Programme.

These three examples justify the need of carefully conducted research to solve national health problems rather than relying on knowledge generated elsewhere.

Bio-environmental Control of Malaria: Concerned with resurgence of malaria, increasing resistance to pesticides, rising cost and health consequences of newly developed ones, emergence of drug-resistant parasites, it became obvious that a new strategy need to be evolved to fight this menace. The Malaria Research Centre experimented with alternate regimes of bio-environmental control to suit the locale-specific requirements of different geographical sites in the country (for details see chapter on ICMR).

Kyasanur Forest Disease (KFD): A viral disease emerging as a consequence of deforestation in Karnataka was investigated by the National Institute of Virology, Pune. Not only was the virus identified but the puzzle of the origin and persistence of KFD virus in nature could be solved. A formalized vaccine was prepared.

Several such examples could be added but special mention may be made of the recent epidemiological studies on cholera epidemic caused by a new strain 0139 and the hepatitis E epidemic

Iodine Deficiency Disorders: Before and After Salt Iodination

Location	Prevalence of Goitre		% of Children with UIE < 5,ug/dl (Iodine deficiency)		% Hypothyroidism among school children		Neonatal Hypothyroidism; incidence per 1,000 births	
	Pre-Iodination	Post-Iodination	Pre-Iodination	Post-Iodination	Pre-Iodination	Post-Iodination	Pre-Iodination	Post-Iodination
Delhi	55%	21.8%	70%	0.64%	-	-	-	-
Gonda	70%	25.8%	>50%	0.75%	21%	<1%	75	9

Iodine deficiency disorders: Before and after salt iodination (Courtesy: N.Kochupillai)

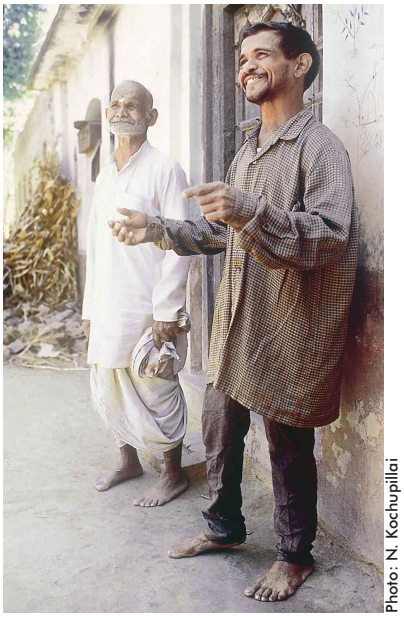


Photo: N. Kochupillai

A case of endemic thyroid goitre (left) and mentally retarded progeny of a mother with severe iodine deficiency (right).

in Kanpur. Needless to reiterate, these studies could only be done in India, by scientists fully trained and equipped with latest techniques and technologies.

Basic Science Research

Demands of clinical work and urgent needs for tackling mounting public health problems did not permit as much attention to basic medical science research as requires. Nevertheless, a number of dedicated teams in practically every discipline of basic sciences — anatomy, physiology, biochemistry, microbiology, pharmacology, and pathology— advanced the frontiers of knowledge. In recent years, with the advent of molecular biology, immunology, biotechnology, genetics and genetic engineering there has been a rapid expansion in the base of biomedical research. Most of these researches have also been directed to address problems of national interest or areas of expertise of individuals or groups. Once again, the following have been cited as representative examples. This should not detract from the value of a large number of other works not included here.

Neurophysiological Investigations: The demonstration of well defined feeding and satiety centres in the hypothalamus of different species of animals, was followed by the studies on reflex mechanisms at the spinal cord and brain stem level, as also the role of feed back from the periphery. Comprehensive studies on the role of limbic system were carried out. Mechanism of sleep, wakefulness, and yogic state were explored.

J-receptors and Other Visceral Receptors: Spread over nearly five decades, persistent efforts at VP Chest Institute of University of Delhi, have revolutionized visceral physiology. Beginning with type B atrial receptors, successively, gastric stretch receptors, ventricular pressure receptors, J-receptors (juxta pulmonary capillary receptors), mucosal mechano receptors of the intestines and pressure-pain receptors of muscle were identified. J-receptors have acquired special relevance owing to the role they play in producing breathlessness and respiratory sensations leading to dry cough.

High Altitude Physiology: Soldiers guarding our frontiers at the inhospitable Himalayan peaks were found to suffer from life threatening pulmonary oedema and other physiological disorders. Pioneering researches by a group at AIIMS led by Sujoy B. Roy and his colleagues, as also by scientists from the Defence Research Laboratories and their collaborators have unravelled the underlying physio-pathology, leading to a management strategy practically abolishing the risks.

Nutritional Pathology: Starting with the initial studies of scientists at the Nutritional Research Laboratories, Coonoor, several major groups in the country at Delhi, Hyderabad, Vadodara,

Chandigarh, Varanasi, Vellore and Bangalore explored the various facets of nutritional deficiency in a variety of animal models and also human beings. These included morphological, biochemical and behavioural effects of not only protein-calorie malnutrition but also micro-nutrient deficiencies including iron, iodine, magnesium and various vitamins specially vitamin A, folic acid, Vitamin B 6 and B12. Simultaneously studies were carried out to evaluate the effect of corrective replacement at various stages of development. On the basis of these studies, national programmes were initiated to overcome their adverse effects on human health.

Immunology Approaches to Fertility Control: Population explosion being a subject of national concern, a variety of programmes and research strategies were initiated from time to time. One such novel approach was the immunological control of fertility using anti-hCG vaccine in females and anti FSH vaccine for males. At the same time another interesting approach was based on active immunization against riboflavin carrier protein to suppress pregnancy. Preliminary data and even clinical trials provided promising results. Unfortunately, there still remain several unresolved problems in applying these for control of fertility.

Molecular Biology of Malarial Parasite: A number of groups in the country specially those at IISc, Bangalore, AIIMS, ICGEB, NII, Malaria Research Centre (all at Delhi) and CDRI, Lucknow, have been exploring the various facets of molecular biology and biochemistry of malarial parasite specially *Plasmodium falciparum*. As a result of these studies efforts are going on to develop one or more vaccines. Major progress has been made in understanding the basis for chloroquin resistance. It was shown that the resistant strains of parasite have significantly higher levels of cytochrome P450. More recently, it has been demonstrated for the first time that intraerythrocytic stage of the malarial parasite degrades haemoglobin and utilizes the amino acids, thus generated for making its own proteins and also generate large quantities of heme sufficient to meet its own requirements. The latest discovery of fatty acid synthesis pathway in the malarial parasite and its inhibition by hydroxy-diphenyl ethers opens up new targets for drug development.

Professor V. Ramalingaswami

Professor V.Ramalingaswami (1921-2001), FNA, FRS, Past-President of INSA, was one of the most illustrious scientists of India, who gave a new direction to biomedical research. He initiated a paradigm shift by extending the sophistication of laboratory research to the bed-sides of the hospital and to the outreaches of the community in remote areas. His major scientific work consisted of studies on nutritional pathology, specially protein-calorie malnutrition, iodine deficiency disorders and nutritional anaemia. His studies on liver diseases in the tropics including Indian Childhood Cirrhosis, Non-Cirrhotic Portal Hypertension. The pathogenesis of so-called Nutritional Cirrhosis bear the stamp of scientific excellence. As Director of the AIIMS, he gave a new direction to education and as Director-General of the ICMR, provided new impetus to strengthen relevant and yet excellent research. He guided the national programmes and policies on health care delivery and research and generously extended his expertise to world bodies such as WHO, UNICEF and IDRC.

Clinical Research

Overburdened with demands for patient care services notwithstanding, astute clinicians have made significant dents in clinical research. Delineating the profile of known diseases affecting local population, defining their natural history, developing appropriate diagnostic and therapeutic

regimes (often at variance with the established practices), identifying new disease entities and syndromes have helped raise the standards of medical care and research. More recently, increasing collaboration between clinicians and biomedical scientists has provided rich dividends. Once again the following account is highly selective and may not necessarily represent the most outstanding.

Rheumatic Fever (RF) and Rheumatic Heart Disease (RHD): It was generally believed that RF and therefore RHD did not occur in tropical India. It was left to the astute observations of K.L. Wig to disprove this notion. The large number of cases of rheumatic valvular disease, which constitute a sizeable percentage of any cardiac-surgeon's work bear testimony to the continuing curse of these disorders. A syndrome of juvenile mitral stenosis has come to be recognized.

Indian Childhood Cirrhosis: As the name suggests this disease, affecting young children in India, attracted a number of studies by pathologists, nutrition experts and paediatricians. Even though its real etiology still remains a mystery, its morbidity and mortality have been markedly reduced.

Non-Cirrhotic Portal Hypertension: A clinical syndrome, quite different from the well known post-cirrhotic variety, was delineated, its pathology and clinical picture elaborated and appropriate therapy standardized as a collaborative effort of scientists from different centres in the country. It may be pointed out that studies by Professor V.Ramalingaswami and colleagues, established that the well-entranched term — Nutritional Cirrhosis, was a misnomer.

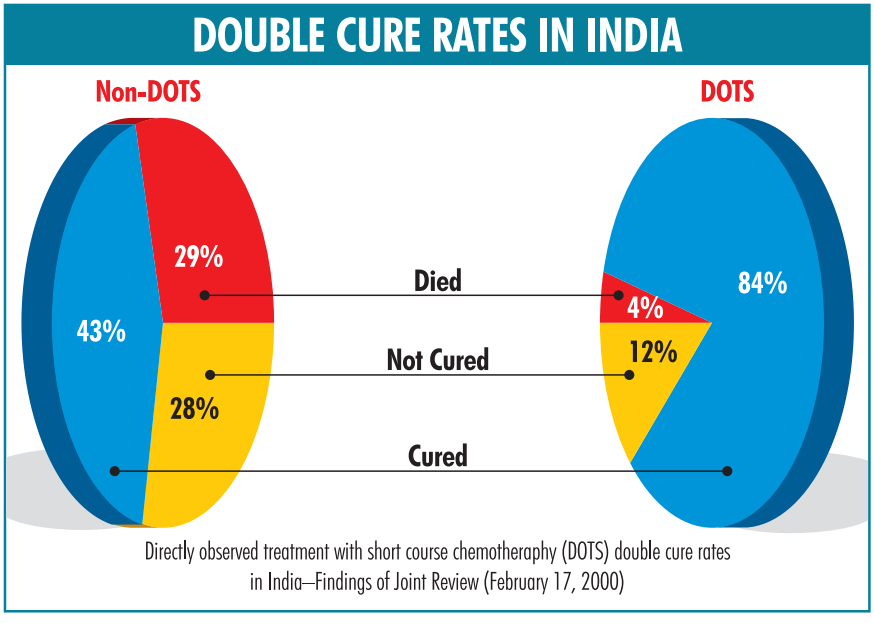
Endomyocardial Fibrosis: A devastating heart disease, usually terminating fatally has been the subject of careful studies. There is evidence to suggest that magnesium deficiency and higher levels of cerium may be responsible for this disorder. This finds support in an experimental animal model developed for further studies. The geochemical basis of this disorder has attracted wide scientific attention.

Tuberculosis including neurotuberculosis: The high prevalence of this disease with its protean manifestations, affecting practically every organ of the body, defying most conventional strategies to control it, has not surprisingly been the subject of many pioneering and now internationally recognized studies. The short-term chemotherapy and the supervised domicilliary treatment in place of sanatorial management are just two of these. All aspects of neurotuberculosis — pathology and pathogenesis, variety of clinical syndromes, diagnostic criteria and management strategies — have been critically documented using the latest microbiological, immunological and imaging techniques. Based on these studies medical treatment for intracranial tuberculomas has replaced the usual surgical management earlier advocated. These contributions have been internationally recognized as is obvious from the following statment, *In more recent years, the major contributions on both pathology and varied clinical manifestations of tuberculosis of the brain and spinal cord have come from workers in India,* ------- (R. Kocen in Infections of the Nervous System edited by P.G.E. Kennedy and R.D. Johnson,

ALL ASPECTS OF NEUROTUBERCULOSIS — PATHOLOGY AND PATHOGENESIS, VARIETY OF CLINICAL SYNDROMES, DIAGNOSTIC CRITERIA AND MANAGEMENT STRATEGIES — HAVE BEEN CRITICALLY DOCUMENTED.

Butterworth, London 1987).

Leprosy: Beginning with the original work of Dharmendra and Khanolkar, a large number of past and present leprologists have contributed to a better understanding of this disease. These studies include clinical classification, immunology, pathology, reconstructive surgery and more recently development of at least two vaccines, which are by far the best so far available.



Directly observed treatment with short course chemotheraphy (DOTS) double cure rates in India—Findings of Joint Review (February 17, 2000)

Diarrhoeal Diseases: Ravaged by a host of pathogens resulting in loss of thousands of lives every year, especially children, biomedical scientists in India have continuously been engaged in research in these disorders. Just to name a few, the identification of cholera exotoxin, detection of a new cholera toxin, mapping the *vibrio cholera* genome, national surveillance of the epidemics, role of rehydration therapy and more recently development of a candidate vaccine which is already in limited phase II trial, deserve special mention. In addition to cholera other enteropathogens causing diarrhoea such as enterotoxigenic *E.coli*, shigellosis, amoebiasis, giardiasis and rotavirus have been thoroughly investigated. Recently two rotavirus candidate vaccines have been developed in collaboration with the US scientists under the Indo-US Vaccine Action Programme (VAP).

Leprosy: before (top) and after (below) combined chemotheraphy and immunotheraphy.

Lest it is understood that biomedical research in India has mainly concentrated on infectious disease, it may be mentioned that outstanding investigations have been carried on in other fields as well. Limitation of space does not permit a detailed account, but mention is made of epidemiology and etiopathogenesis of cataract, tobacco and arecanut related oral cancer and cervical carcinoma, coronary heart disease, atherosclerosis (clinical and experimental studies), stroke in young, neurolathyrism (including identification of its toxic factor BOAA from the grain legume *Lathyrus sativus*), veno-occlusive disease of liver (role of aflatoxins in its causation) and epidemic dropsy (caused by *Argemone mexicana* toxin).

Psychology: In the earlier years, like most other subjects, psychology education and research, followed the directions set in the West. However, it soon became obvious, that the subject is deeply rooted in the socio-cultural milieu of a community hence the 'tools' used for its study, cannot be directly adopted from other cultures. These were, therefore, modified tested and standardized for local use. Mention may be made of the work of Bhatia, Kamath and more recently of the work at PGIMER, Chandigarh, and NIMHANS, Bangalore, among others. Similarly the national needs dictated the direction of research in the fields of social psychology, industrial psychology, education psychology and anthropological studies on special population groups like tribals, or professionals like armed force personnel, or clinical psychology to evaluate patients with mental and neurological disorders and more recently persons at risk for sexually transmitted disorders and HIV / AIDS infection. This is not to say that work on more basic areas, including experimental psychology, cognitive science, or developmental and cross-cultural psychology of a very high calibre was not carried out.

Psychiatry & Mental Health: Research on psychiatry and mental health in India has progressed from hospital based descriptions of clinical syndromes to epidemiological and outcome studies. The clinical studies have contributed to the international recognition and acceptance of the syndrome of acute, brief psychoses which are seen to occur more in the Afro-Asian Region. Research on outcome of severe illnesses like schizophrenia have indicated more favourable outcome in 'developing' countries like India, attributed to the higher level of family and social support available in these societies.

The specific role of the social and cultural factors in depression has been studied, along with the study of suicide. Clinical and Biological Research on Depression and other disorders like obsessional disorders and groups of disorders like Substance Use Disorders has also been carried out, in the past few decades. Community based research on extending the mental health services to primary case has been processed at a few centres and is being applied as a service programme.

Neuroscience: A number of important contributions in the field of neurosciences — both basic and clinical have recently been summarized in a paper, *Neurosciences in India: An Overview (Annals of Indian Academy of Neurology*, **3**, 3–21, 2001) and hence only a brief summary is included here.

Some of the important contributions to neurophysiology and neuropharmacology are mentioned elsewhere. Major additions to knowledge have been made in the field of developmental neurobiology which include neuromorphological studies on developing embryo, both animal and human in respect to spinal cord, visual system and cerebellum. A large number of studies have dealt with morphological, biochemical and behavioural consequences of under-nutrition and malnutrition. At the other end a number of investigators have elucidated the biology of aging brain. Foetal neural transplant in rodents and monkeys provided valuable insights in its utility and pitfalls for replacing damage or degenerating brain tissue. Neurochemists in the country including B.K.Bachhawat put India on the international map. A major research outcome of his group has been tracing the biosynthetic pathway of cerebroside-3-sulphate and other enzymes associated with sulphate metabolism. For the first time it was established that deficiency of an enzyme (arylsulphatase A) was responsible for metachromatic leucodystrophy - an inborn error of metabolism. This tradition of pursuing neurochemistry is being carried forward. Similarly researchers at IISc and NIMHANS, Bangalore, and ITRC, Lucknow, alongwith a number of clinicians have done pioneering work on neurotoxicology specially in respect to neurolathyrism and pesticide toxicity. The underlying pathogenetic mechanism, including the role of cytochrome P450 in xenobiotic metabolism and detoxification of drugs

and toxins deserve special mention.

The clinical neuroscientists along with neuropathologists were primarily concerned with delineating the pattern of neurological disorders as seen in India, establishing the differences in their manifestations and natural history, laying down diagnostic criteria and guidelines for therapy. Not surprisingly most of the internationally acclaimed investigations belong to the areas of infective disorders and epidemiology. In addition, significant studies were made in the field of congenital malformations, epilepsy, stroke and subarachnoid haemorrhage and neural trauma.

Biotechnological Approaches for Development of Immunodiagnostics, Immunomodulators, Vaccines, Immunotherapeutics and Gene Therapy: Several diagnostic kits have been developed during the last few years. This became necessary not only because the imported kits were expensive but often these were not based on the prevalent strains of pathogens in the country. These include diagnostic kits for malaria, filaria, leischmania, hepatitis, HIV / AIDS, α-foetoprotein. A PCR based diagnostic kit for tuberculosis is in the final stages of validation.

In addition to the leprosy vaccine mentioned earlier, hepatitis B vaccine based on indigenous efforts is already in the market. A candidate vaccine against cholera is currently in Phase II trial. Two rota -virus vaccines have completed Phase I trial and have been approved for limits Phase II trials. Work on candidate vaccines for Japanese encephalitis, malaria, tuberculosis and rabies is being pursued vigorously.

Miscellaneous

There has been renewed interest in scientifically establishing the value of traditional medicines, several of these are undergoing clinical trials. Thus a variety of uses of neem oil as a bactericidal, spermicidal and mosquito repellant have been established scientifically. Similarly the antioxidant, anti-inflammatory and anticarcinogenic properties of turmeric and curcumin have been evaluated. Some traditional health promoting practices like yoga and meditation, are being critically evaluated utilizing the latest scientific tools and techniques. At the same time as a result of researches in our laboratories, the country has developed indigenous capability to produce a number of bulk drugs and expensive imported drugs and make them available at affordable price by innovative process development e.g. AZT, vincristine and others.

At least a few biomedical devices, based on researches in the country, are already in the market. These include the well known Jaipur foot for amputees, shunts for treatment of hydrocephalus and an indigenously devised Tilting Disc Cardiac Valve and Spectra Oxygenator.

In conclusion, this very brief review should convince any one of the immense strides that medical science has made in India during the past 50 years. Compared to the developments in the 50 years preceeding Independence, there has been a quantum jump. Nevertheless, a great deal needs to be done if we have to meet the growing health needs of our people and share our knowledge with others, specially developing nations in this era of globalization.