

## INTRODUCTION

Technical innovation is considered to have played an important role in the profound transformations that have taken place over the past century in medicine and in delivery of medical care through public health systems, by making available effective preventive, diagnostic and therapeutic tools. The most visible of these changes are the extensive use of instruments and equipment, ranging from the simple to the very complex, the centering of medical care in hospitals and the rise of the specialist and various specialties and sub-specialties, all features characterized as 'high-tech' or 'state-of-the-art' medicine. Bronzino's description of medical technology captures the understanding among the lay public as well as the academic community of technology. According to him, 'The origins of the changes that occurred within medical practice are found in the rapid developments that took place in the applied sciences (chemistry, physics, engineering, microbiology, physiology, pharmacology, and so on) at the turn of the century. This process of development was characterized by intense cross-fertilization able to take giant strides forward in the development of techniques for diagnosis and treatment of disease.....New discoveries in medical science followed one another like intermediates in a chain reaction' (Bronzino *et al* 1990).

Much of the influx of technology into medicine began in the industrialized countries of the west in the latter decades of the nineteenth century. It took firm roots by mid-twentieth century, and has become an indistinguishable component of present-day medical practice and health-care systems. Indeed, the term *health care technology* is used by many to denote medical technology. The latter is an important form of technology in modern society. To a very large extent in the industrialized countries of the West, and much acclaimed and adopted in nearly all developing countries such as India, medical care is now provided through complex hierarchical delivery systems, involving sophisticated science, state-of-the-art technology, and numerous specialized personnel. The use of technology in medicine is accepted as natural and given, as an inevitable and desirable feature of medical practice and healthcare. It is so intensive that the modern-day physician has been described by some as the prototype of the 'technological man'. Furthermore, it is predicted that technological change in medicine will continue to accelerate. Technical innovations and medical inventions over the last century have been impressive. It is not surprising therefore that there is an aura around all technology, arising from notions of the inevitability of 'advances in science and technology', and of such advances as 'progress', and medical technology is no exception.

Modern western science and technology were adopted by the policy-makers in post-Independent India as the 'engine' for the growth and development of industrialization, increasing agricultural productivity, and improving people's health. Assuming that modern western science was the main engine that had ushered progress in the west in the early 20<sup>th</sup> century, great faith was and is reposed in the promise of modern western science and technology, including modern medicine, to bring about 'a better tomorrow'. Assuming advances in these areas to be the basis of good medical care and public health systems, the scientific community in India is exhorted to undertake research to address problems identified by the policy-makers as impediments to growth, and to provide solutions to these and contribute towards the development and advancement of the country.

Despite such faith, and the vast resources that have been spent in setting up scientific and medical institutions of education, training, research and development in India, in areas such as public health we see that problems that had been long addressed in other countries still constitute the bulk of our problems. For instance: over a hundred years after the etiology of malaria had been established (that too from research in India), and after malaria had ceased to be a public health problem in many other countries, we in India are being asked to harness the 'new biotechnology revolution', to develop now a vaccine for malaria, which remains a major public health problem in the country! Similarly, while the Green Revolution in India was nationally and internationally hailed as a major success in agriculture that had made the country self-sufficient in food-grains, malnutrition, hunger and starvation deaths are being reported from several parts of the country. Several infectious diseases – tuberculosis, respiratory infections, water-borne infections such as cholera, childhood diseases – that had ceased to be public health problems in the western countries (and in certain developing countries as well), ostensibly due to availability of modern medicines and vaccines, constitute major public health problems in India. Strangely this was seen as evidence for promoting technological interventions even more aggressively, rather than looking at the range of issues involved from a more critical and holistic perspective. Thus the crying need to improve the distribution of the available food grains was never accorded priority, and the redressal remains focused on enhancing agricultural productivity. Similarly, the linkage between nutrition and infection remains poorly studied, even while development of new generation antibiotics and vaccines, rapid diagnostic kits, or targeted drug delivery systems are hot areas of bio-medical research. The overall health indicators continue to remain poor.

As a working scientist, one also saw that this belief was instrumental in the creation of many institutions in the country for advanced scientific and medical research and that these

research institutions, hospitals, etc., were well-endowed with the latest and the best technologies, with 'state-of-the art' equipment and facilities, and access to the international communities and their research. We had substantial number of scientific and medical personnel, and highly trained ones for that matter. So we seemed to be faced with an astounding paradox – we had the best available technologies at the disposal of highly trained scientists and doctors, to deliver means of diagnosis and cure for a range of health problems, ranging from the apparently simple to the complex. However, there were only marginal improvements. Questions arose as to why the existing technical means had not been effective, what could be better or novel technologies. Resolving this paradox implied examining the origins of this apparent faith in technology, addressing questions about the role of technology, specifically of medical technology, of what went behind development of medical technologies as 'panaceas', and of the organization of health systems through which these technologies were delivered, to grasp and understand the nature of the problems.

The complexity involved in unraveling medical technology is reflected in the very definition of technology itself. The term 'technology' has several meanings in modern societies. It is used to refer to an artifact/device/ machine, as well as to a specialized form of theoretical knowledge or expertise, a distinctive mental style and a unique set of skills and practices. In fact in many instances 'technology' is identified less closely with the material aspect and is much more an abstract concept, denoting the association of the machine with certain kinds of knowledge, practices and organizational styles<sup>1</sup>. The term 'medical technology' is also used as an abstract inclusive term that refers to the elements of contemporary medical practice. Such as the set of procedures, techniques, drugs and equipment used by medical professionals in delivery of medical care, as well as the systems within which such care is delivered.

In addition, perusal of analyses of medical technology by medical professionals cast a shadow on the dominant views of medical technology. Firstly, that it emerges from scientific-medical research, which progresses due to an inherent logic. It also questioned the notion that technology is evaluated and adopted by the medical profession because of the inherent advantages that it conferred on their practice. Thirdly, it brought into focus the conflicts within modern medicine over the role and use of technology in diagnosis, curing and healing. There were debates within the medical profession, and reservations and concerns among sections of medical professionals over the impact of these developments on medical practice - about the

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<sup>1</sup> Marx (1994) discusses the change in the idea of 'technology' over the nineteenth century, wherein technology is not just discrete, identifiable artifacts, but includes abstract, scientific and seemingly neutral systems of production and control (technocracy). And finally by late 19<sup>th</sup>-early 20<sup>th</sup> centuries technology got reified and improvements in technology became the basis and measure of progress in society.

tendency for (over)dependence on technology, over its possible gains and losses to medicine. The delegation of responsibility for diagnosis to technical experts had raised basic moral problems for twentieth-century medicine (Reiser 1978 p 171). For example, in the 1950s the hazards of hospitalization were acknowledged and the term "disease of medical progress" was used. Some doctors had documented the 'disturbing incidence of medical misfires', and on the dilemmas posed by the expanding capacity for intervention in human disease, such as the financial burdens for the patients, the 'worrisome incidence' of iatrogenic diseases and the tendency for specialization among physicians (Rogers 1975). There were calls for technologic restraint coupled with discrimination in the use of the 'powerful tools we now have at our command', and to adopt 'a patient-oriented approach to problems rather than a problem-oriented approach to the patient'. An important issue that was sought to be raised throughout, in some way or the other was that of limitations of technologically generated evidence. There were movements within the medical profession in the late nineteenth and early twentieth centuries, by which time technologies like the x-ray and the clinical laboratory had started becoming widespread, which raised important questions about the uncritical reliance of medicine on technologically generated facts (Reiser 1978).

By the mid-twentieth century several problems with medical technology started to be highlighted in the West (specifically USA and Britain), such as the safety, efficacy, costs and cost-effectiveness. There was a general consensus that medical technologies are expensive to acquire and maintain, and substantially contribute to increasing the costs of medical care in a number of ways. The high cost had come to be seen as a problem that needs a solution. Some considered the main problem with high technology medicine (HTM) to be its high cost, which they maintain should somehow be met. Others considered that the root cause of the increasing health-care costs lay in too much technology, which they felt should somehow be regulated. Since the 1970s 'high technology medicine' has also been the target for critics of modern medicine. It has come to be described in a variety of negative terms - expensive, esoteric, elaborate, mechanical, and inhumane, an expression of power, and so on. A powerful critique of medicine was propounded by Illich. He analyzed clinical iatrogenesis – where pain, sickness and death result from provision of medical care – as a problem of industrialization of society, and industrialization of medicine (Illich 1975).

Hence, there has been a lot of writing about the technology of medicine. about its nature, cost and effects. As pointed out by Jenet, for some 'high-technology medicine is a blessing. a saviour, while to others it is a burden, a scapegoat; to some it is a milestone marking progress in medicine; to others it is a millstone holding back progress towards the millennium of preventive

and holistic medicine.....' (Jennett 1984). In fact, Jennett documents and discusses the range of concerns and criticisms brought against medicine and its technology, by a range of scholars including medical professionals from the USA and UK (Jennett 1984 pp 127-132). As best put by Leo Marx,

“..... for example, modern advances in medicine and social hygiene are perhaps the most widely admired realm of science-based technological advances; nonetheless, it is often said today that those alleged advances are as much a curse as a blessing” (Marx 1994 p 239).

It was evident then that technology was a contested subject within the medical profession, and there were unresolved issues regarding the dependence upon and use of so much technology. In spite of so much writing on medical technology gaps still remained. Several areas enumerated earlier have not been given adequate attention – such as the root causes of the problems identified. Further, not much is known about the development and production of innovations, both high-tech and routinely used medical instruments and equipment. Furthermore: the cost aspect of high-technology medicine (HTM) begged the question: why is it that (advanced/new) medical technology is often more expensive and more specialized? What is it about novel technology that makes it expensive to acquire and use? Is it possible to have simpler, less expensive/cheaper technology? Yet, these were questions that were conspicuous by their absence in most analyses of technology in medicine. The problems identified were viewed as a necessary cost that one has to pay for the putative benefits.

This study attempts to address some of the gaps identified above in relation to medical technologies and their place in medicine and public health, especially in the Indian context. The study is restricted to examination of equipment-embodied medical technologies – a much-neglected area of medical technology, in sharp contrast to the vast literature on the drugs and pharmaceutical industry. The intention is to highlight dimensions of medical technology not very evident or not generally considered, and their significance and implications for public health.

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Medical technology, being positioned at the intersection of health and medicine, its study poses several challenges and prospects. At one level it can be a way of looking at the inter-relationships between the three –medicine, public health and technology within a health system. On the other hand, analysis of technology in medicine can be a way of posing questions about technology, in general, in modern societies. Yet another dimension of medical technology is that, given its ramifications, its immediate and intimate importance to individual lives, and

pervasiveness and importance in modern societies in general, it offers a concrete instance of what can be described as *'technology-in-society'*, and hence an opportunity for exploration of technology-society interface. This study largely takes up issues of the first kind in the Indian context and then raises issues about the general characteristics of its links with global medical technology.

It became evident that to explore these questions about medical technology, an important issue was also that of finding an appropriate framework for the inquiry. This work is based upon the understanding that technologies do not simply appear from the blue and then force us to accept them or reject them. The assumption underlying this work is that technology itself is a product of social processes and social choices. ~~While there are limits imposed by physical laws, issues of design, feasibility, etc., still there could be several options in technologies, and the choice of a particular technology is guided by several social considerations.~~ Analysis of technology without considering the social context of its origins, development and use tends to be incomplete, and therefore incapable of resolving the dilemmas and problems arising from technology. In addition, the development and diffusion of medical technology involves several actors and sites. It cannot be understood solely with reference to merely technology or to medicine, but needs insights from both areas. Therefore, medical technology is best understood within a broad systems paradigm, incorporating a structural-historical-dialectical approach.

This thesis is laid out over eight chapters. Chapter I discusses the competing perspectives guiding studies of technology and technological innovations, in general (Section I), and medical technologies in particular (Section II). It examines how, since the Second World War, critical perspectives arose on science and technology as a counter to the dominant notion of technological determinism, and the kind of academic turn these studies later took. It discusses the shortcomings and potential of the respective approaches to technology, namely those of technological determinism, social shaping and social constructivism. We see that there is substantial literature on impact of medical technology in the industrialized countries of the West, a large chunk of it on the impact of medical technology on cost of healthcare, and on regulatory mechanisms. These range from evaluation by medical professionals of the so-called *'technical aspects'* such as the clinical usefulness and their efficacy, to a large number of studies undertaken from a policy angle. Since the 1970s medical technology assessment/technology assessment in health care has developed into an independent area of study. Medical technology has been recognized as a central issue also in the sociology of health and illness. Interesting criticisms of medical technology have emerged from some women's groups, and from disabled persons. By and large, many of these studies do not move beyond the level of the role of the

doctor, and blame largely the profession for all the woes and problems of technology; or, used medical technology to construct a case against medical hegemony. Despite a lot being written about the economic and social impact of medical technology, nothing clearly emerges about the nature and genesis of the problems regarding medical technology, nor how they can be resolved.

Chapter 2 then looks at the relation between technology, medicine and public health in the West. It examines the history of public health to understand the process of dominance of modern medicine in public health, and the development of the relation between technology, medicine and industry. Review of the formative period of modern public health through 19<sup>th</sup> century in Europe shows that there were vigorous debates regarding health, illness and disease causation. There were differences in the primacy accorded to the role of poverty, of living and working conditions, of effect of starvation, of sanitation, on the health of populations. There were different conceptions and different philosophies with different implications for public health activities that could be taken up. The choices made then regarding the very definition of health, and role of technology, have had extremely far-reaching implications for modern public health and medicine. We find that scientific medicine also had equally important economic and social origins. Beginning in that period, concrete scientific developments led to the application of scientific thought and investigation to problems of disease, and the results were adopted by the reformers of medicine as an essential component of the medical reform process. The growth and influence of organized 'scientific' medicine came about not simply through cultural assimilation or through the demands of industrial organization, but also by professionals, philanthropic organizations and the state, that acted on its behalf. This history has shaped a medical and healthcare system that is now dominant in the USA, and has been carried to, or adopted, with or without modifications, in most parts of the world, including India. The subsequent growth of medicine and healthcare has continued in the context of consolidation of industrial capitalism, as well as its spread to former colonies. The organization of public health institutions has been in keeping with the needs and demands of industrialized capitalist economies. It is highly influenced by the glamour of technology as reflected in the institutions of these capitalist societies and their medical care and health systems.

The origins in India of the healthcare system and modern medicine is then traced to the colonial period, and since then as an outcome of interactions between several kinds of economic and social forces and interests – both national and international. Chapter 3 reviews these developments in public health, medical services and medical education in India. The place of medical technology in India is discussed in light of the specific choices and policies made during and after the colonial period. These have been the choices of those who brought in

modern medicine and a technology-based public health system to the colonies and those who were trained by them to administer in the post independent period. Influence of international institutions, subsequent attempts at self-sufficiency by the state, and the emergence of the present international environment with its neo-liberal policies and its implications for the medical equipment and healthcare industry are discussed here. It emerges that healthcare systems and use of medical technology in India have been influenced by western institutions and have features in common with the western experience. At the same time, there are divergences, given the different social context and the history of over two hundred years of colonization.

Chapter 4 defines the research problem and the framework that guides this study of medical technology, against the background of the perspectives and observations discussed in the previous three chapters. Unlike studies of a specific medical technology that so far have been undertaken for solely policy purposes, or from a sociological or economic approach, and therefore have been guided by the dominant perspectives within that discipline, this work is motivated largely by public health concerns regarding medical technology. This study adopts the more recent advancements in *social shaping of technology* giving rise to critical radical analysis, and the political economy analysis of medical care and health systems arising out of the *social medicine* perspective. Medical technologies are viewed as part of modern societies, and of medical care and public health systems. This enables an understanding simultaneously of the social shaping of health, medicine and public health, as well as the technologies that are part of these systems. The study of development and diffusion of medical technology in India is situated in the context of the developments in the larger public healthcare system, and both are examined in a historical framework that incorporates the economic and political context, and also devotes attention to the actual technology itself.

Questions around medical innovations and criteria and considerations in choice of medical technology; manufacturing and trade; providers and users of medical technology at the international level and in India, are covered in Chapters 5, 6 & 7. These chapters present and analyze trends in production, imports, investments, and characteristics of the medical equipment industry based on data collected from governmental and other sources. Chapter 5 is in two sections. Section I looks at specific case studies of development of medical equipment, especially imaging equipment, to illustrate some general points about the development of medical technology, the complexity of the process, and to draw out considerations guiding the development and adoption of medical innovations. The second section presents the characteristics of the global medical equipment and devices industry. It presents information on

the overall trends in market size, manufacture and trade; at key players in the industry, especially the multinational companies. It also looks at the activities of the industry other than that of manufacturing, such as in training, education and research, in financing, in marketing and lobbying, and at the strategies being devised *to tap growing healthcare markets in developing countries*, as advocated by most market surveys and reports of the industry. Chapter 6 presents data on the medical equipment and devices industry in India, an important component of the “rising healthcare industry” here. It begins by examining the policy and planning for medical equipment in India since 1947. As was done in Chapter 5 with regard to the international equipment industry, this chapter presents information for India on the overall trends in market size, manufacture and trade; at key players in the industry, especially the multinational companies. It also looks at the activities of the industry other than that of manufacturing, such as in training, education and research, in financing, in marketing and lobbying, and at the strategies being devised to promote imaging technologies, to create demand. Chapter 7 presents information on the purchasers and providers of medical technologies in India – namely hospitals and diagnostic centers in the private and public sectors. It analyzes the factors contributing to the observed expansion of both, medical equipment and to their use in the private sector and their links with the state of affairs in the public sector.

Two central issues that emerge from our exploration of medical technology are discussed in Chapter 8. These are respectively: the analytical framework for study of medical technology, and secondly, the factors that impinge upon and shape medical technology in a given social context. |scvs

As mentioned earlier this study has its genesis in questions about medical technology and persistence of large-scale morbidity and mortality from seemingly tractable diseases amidst vast financial inputs into technical resources. Hence it seeks, first and foremost, to provide a coherent social underpinning to the emergence of medical technology, and shed some light on at least some of these problems in the Western, as well as the Indian context. It seeks to explicitly bring the ‘social’ into the analysis and understanding of the socially significant activities of science and technology, of modern medicine and public health. In the studies on India the socio-economic and public health context of medical technologies has not been addressed from any quarter. Not all technologies have been covered, given the human constraints, and so we have selected some key medical technologies for our exploration. Thirdly, as against the innumerable studies of individual medical technologies, rooted in a reductionist approach, this study examines the selected medical technologies as part of an interdependent system of public health and medicine in an industrializing capitalist society. Lastly, it uses an inter-disciplinary

approach, and incorporates studies from history of public health, sociological studies of medical innovations, studies by medical professionals, policy studies - with the information collected on the contemporary situation unfolding in India.

So far the sociological inquiry of technology has largely been swinging between the dichotomies of 'good'- 'bad', between 'glorification' - 'vilification', and has not led to an effective and meaningful resolution of the problems of technology in modern societies. Regarding medical technology it has been said that an exploration of high technology medicine (HTM) "is an exploration of the paradoxes that await anyone anxious to study this problem, the ambivalence of attitudes that the topic provokes and of the real difficulties that lie ahead for those wishing to do something practical to ensure that we make better use of technology in the future" (Jennett 1984 p 132).

While we agree that it is a challenging task, and are appreciative of the problems, however, it is well within the realm of a *critical inquiry*. This study avoids the pitfalls of the blessing - curse dichotomy, and argues for a critical perspective of medical technology, based on systematic examination of the social structures and technologies of the modern, the present in light of the developments rooted in the past. By bringing out the socially constructed nature of medical technologies, our work builds on the large body of earlier work on this subject, and demonstrates that there is nothing inevitable, no 'imperative' about technologies. Hence, there exist possibilities of change, of re-orienting, of re-shaping modern medical technologies and health systems to a different kind of rationality. There exist possibilities of asking and addressing questions such as what sort of measures would be appropriate for preservation of health, for prevention, cure and care, what sort of medical and healthcare we want, and what our priorities are. In other words, our analysis brings out, and underlines as well, the socio-political nature of the problems and challenges in the realm of medical technology. Through such a study one hopes to have taken a meaningful step towards an understanding of the paradoxes and concerns with which we are faced, with which this quest commenced in the first place, and towards their humane and scientific resolution.

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*Must human beings submit to the harsh logic of machinery, or can technology be fundamentally redesigned to better serve its creators? This is the ultimate question on which the future of industrial civilization depends. It is not primarily a technical question but concerns a fundamental issue in social philosophy, the neutrality of technology and the related theory of technology determinism. If technology is neutral, then its immense and often disturbing social and environmental impacts are accidental side effects of progress. Much current debate polarizes around the question of whether these side-effects outweigh the benefits. The advocates of further progress claim "reason" as their ally, while the adversaries defend "humanity" against machines and mechanistic social organizations. The stage is set for a struggle for and against technology.*

*.....the real issue is not technology or progress per se but the variety of possible technologies and paths of progress among which we must choose. Determinists claim that there are no such alternatives, that technological advance always and everywhere leads to the same result. This view is increasingly contested by students of technology. But if alternatives do exist, the choice between them will have political implications.*

*Modern technology.....embodies the values of a particular civilization and especially those of elites that rest their claims to hegemony on technical mastery. We must articulate and judge these values in a cultural critique of technology.....This project requires a different sort of thinking from the dominant technological rationality, a critical rationality capable of reflecting on the larger context of technology.*

- Andrew Feenberg (2002)<sup>1</sup>

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<sup>1</sup> In: *Transforming Technology: A Critical Theory Revisited*, Oxford University Press, New York.