HEALTH INNOVATION SYSTEMS IN DEVELOPING COUNTRIES
Strategies for Building Scientific and Technological Capacities

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WORKING DRAFT

INTRODUCTION

There is a growing recognition that the extent to which developing countries will be able to reduce the burden of disease and achieve health related Millennium Development Goals (MDGs) will depend on whether and how well they build their capacities to harness and apply science and technology. This recognition is articulated in such international policy documents as the Plan of Implementation adopted at the World Summit on Sustainable Development (2003), *Innovation: Applying Knowledge in Development* (2005)[1], and *Our Common Interest* (2005).[2] These contain explicit references to the role that science and technology play in identifying and solving health challenges associated with disease and improving health care systems of developing countries. They put emphasis on measures—policies and institutions--that would strengthen the scientific and technological capacities of these countries.

Scientific and technological capacities comprise of the quality and quantity of human skills or expertise in a range health disciplines, financial resources for health research and innovation, the nature and effectiveness of research institutions, and how these are configured to mobilize and use human, financial and physical resources. They are also about the existence of public and private institutions dedicated to technological innovations (both processes and products), and the nature of health policies, science and technology policies, and how well these are implemented.

Inequalities in public health between developed and developing countries are, to a large measure, accounted for by differences in scientific and technological capacities.[3] As this paper shows in section 1, India, South Africa, Brazil and China are some of the countries that are making deliberate efforts to build their scientific and technological capacities. These countries are likely to be reducing their disease burden. Although many developing countries are making attempts to improve public health, on the whole their scientific and technological capacities are still limited and not effective. This, in turn, is probably due to limited (and in some cases a lack) of the recognition of the roles that scientific research and technological innovation play in addressing health challenges, particularly fighting disease.

This paper provides an indicative assessment of scientific and technological capacity needs of developing countries to improve public health. It identifies programmatic and institutional measures that are necessary to build scientific and technological capacities. Emphasis is placed on national, regional and international activities to build critical masses of skills, improve health policies, strengthen research institutions, and create agencies that generate process and product innovations in developing countries.

The first section of the paper provides an overview public health challenges that many developing countries are faced with. The section also examines scientific and

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[1] Report of Taskforce 10 (Science, Technology and Innovation) of the United Nations Millennium Project.

[2] Report of the Commission for Africa.

[3] Wagstaff, A. (2002), 'Inequalities in Health in Developing Countries: Swimming Against the Tide?' The World Bank, Washington, DC.; and Freeman, P. and Miller, M. (2001), 'Scientific Capacity Building to Improve Population Health: Knowledge as a Global Public Good'. Report Prepared for the WHO Commission on Health and Macroeconomics.

technological opportunities available to these countries to address the challenges. It shows that many developing countries lack the necessary health research and innovation capacities.

Section two outlines conceptual and methodological issues. It defines the concepts of scientific and technological capacity, health innovation systems, and capacity building. The section also describes methodology for the assessment of scientific and technological capacities. It introduces the concept of national systems of innovation and its applicability to strengthening scientific and technological capacities for improving public health.

The third section focuses on health innovation systems, with emphasis on institutions supporting technical advances for the discovery and production of medicines in innovative developing countries—those that have some resemblance of national health innovation systems. It gives examples of measures that governments have instituted to stimulate innovations in health.

Section four is about regional and international collaboration to build health innovation systems. It shows that a lot more needs to be done to build developing countries' scientific and technological capacities through regional and international collaboration. The last section outlines the need to create leadership for health sciences and innovation, undertake health innovation surveys, build new forms of institutional arrangements, and create international programmes for creating or enhancing skills in innovation policy analysis as some of the strategies to towards the establishment of health innovation capacities in developing countries.

1. DEVELOPING COUNTRIES' HEALTH CHALLENGES

1.1 The Disease Burden and Weak Health Systems

Developing countries are faced with formidable public health challenges: the rapid spread of HIV/AIDS, persistence of malaria and such other killer diseases as tuberculosis. They are also experiencing deterioration of their health infrastructures, and low and declining investments in health research. Life expectancy has fallen considerably in the last two decades in many developing countries particularly those of sub-Saharan Africa. Tuberculosis, malaria and HIV/AIDS together account for nearly 18 percent of the disease burden in the poorest developing countries.[4]

The burden of disease is increasing in many developing countries. Let us take Malawi as an example. Neonatal mortality rate is estimated at 42 per 1000 live births, which is higher than the expected rate for a developing country. This mortality is caused by infections and complications during delivery. Tuberculosis has increased fivefold in the past decade. Of about 30,000 inpatient deaths recorded in 2002, 9% was diagnosed as malnutrition, 7% as tuberculosis, 3% as AIDS 23% as acute

[4] WHO (2004), *World Report on Knowledge for a Better Health: Strengthening Health Systems*. World Health Organization, Geneva, Switzerland.

respiratory tract infections, 9% as diarrhoea, 23% as malaria and 1% as traumatic condition and gynaecological disorder.[5]

In Africa as a whole, the disease burden is also pronounced. The NEPAD Health Strategy estimates that it is increasing. "The HIV/AIDS epidemic poses an unprecedented challenge for Africa, reversing the gains made in life expectancy over the past half century. Life expectancy in the most severely affected countries has been reduced by almost a third, from 60 years to 43 years. 2.4 million people died from AIDS in 2002 and around 3.5 million infections occurred….1 million deaths (are) caused by malaria each year and 600 000 deaths caused by tuberculosis. Malaria has slowed economic growth by 1.3% per annum at a $12 billion economic cost. Countries have a tuberculosis burden exceeding the 300 per 100 000 population benchmark for severe disease, with 1.6 million new active cases occurring annually. Sleeping sickness is resurging, affecting between 300 000 and 500 000 people annually."[6]

Many other developing countries are also confronted with similar health challenges and increasing disease burden. Despite impressive achievements in global health, at least two-thirds of the world's population suffer from burden of illness and premature birth. "Every year an estimated 15 million children—40,000 children per day—die from infection and malnutrition. …. The toll of preventable and curable illness, early death and lifelong disability in developing countries from both communicable and noncommunicable diseases is unjust, immoral and a critical impediment to economic development and social stability."[7]

Inequities in health are widening between developed and developing countries.[8] In 2001 infant mortality rate per 1,000 live births was 9 in developed countries and 90 in developing ones. In the same year prevalence of tuberculosis per 100,000 persons was 144 in developing countries and only 23 in developed ones.[9] "In 1990, communicable diseases caused 59% of death and disability among the world's poorest 20%. Among the world's richest 20%, on the other hand, non-communicable diseases caused 85% of death and disability. A raised baseline rate of communicable disease decline between 1990 and 2020 would increase life-expectancy among the world's poorest 20% around ten times as much as it would the richest 20% (4·1 *vs* 0·4 years). However, the poorest 20% would gain only around a quarter to a third as much as the richest 20% from a similar increase in non-communicable diseases (1·4 *vs* 5·3 years) As a result, a faster decline in communicable diseases would decease the poor-rich gap in 2020, but under an accelerated rate of overall decline in non-communicable diseases, the poor-rich gap would widen."[10]

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[5] Ministry of Health (2003), 'A Joint Programme of Work 2004-2010. Department of Health Planning Services, Lilongwe, Malawi; and Ministry of Health (2004), *Malawi Health Management Information Bulletin*. Ministry of Health, Lilongwe, Malawi.

[6] The New Partnership for Africa's Development (NEPAD), 2003 *Health Strategy*, p. 4.

[7] WHO (2004), *World Report on Knowledge for a Better Health: Strengthening Health Systems*, p.8. World Health Organization, Geneva, Switzerland.

[8] See for example report by the Rockefeller Foundation and Swedish International Development Cooperation Agency (2004) *Challenging Inequities in Health: From Ethics to Action*.

[9] WHO (2004), *World Report on Knowledge for a Better Health: Strengthening Health Systems*, p.8. World Health Organization, Geneva, Switzerland.

[10] Gwatkin, D. et. al. (1999), 'The burden of disease among the global poor' *The Lancet Vol. 354*, No. 9178, August. http://www.apha-ih.org/disparities/Disparities1.htm

A large and growing percentage of developing countries' population has inadequate access to essential medicines and health. It has been estimated that one half of Africa and Asia's populations lacks access to most basic medical remedies.[11] This is because of non-availability of medicines which are accessible elsewhere, particularly in developed countries, and also the failure to develop medicines for major diseases affecting developing countries. Research has been preponderantly directed towards treatments for diseases of the developed countries. It has been estimated that between 1975 and 1997, only 13 of the 1223 new chemical entities found to have useful pharmacological properties were for the treatment of diseases prevalent in poor countries.[12]

Global health inequalities are accounted for by a range of interrelated geopolitical, social, economic and technological factors. These include developing countries' lack of or limited access to global health knowledge and technologies[13], and because most of the developed countries' health research and innovation activities do not target or focus on many of the diseases of the poor. WHO estimates that malaria, tuberculosis, and the strains of HIV prevalent in Africa kill more than five million people each year.[14] Yet relative to this enormous burden, very little research is directed towards these diseases. A growing number of studies show that not more than 10 percent of global health research efforts are devoted to diseases prevalent in developing countries.[15]

Under current conditions, a majority of developing countries are unlikely to met health related targets of the Millennium Development Goals (MDGs). Recent assessments show that indeed many of these countries are behind schedule in achieving the MDGs generally.[16] The extent to which they meet the goals—halt and reverse the spread of HIV/AIDS by 2015, reduce maternal mortality ratio by three-quarters by 2015, and reduce under-five mortality by two-thirds by 2015—and solve other related public health problems depends on whether and how they invest in science and technological innovation. These countries will need to do more to build their capabilities to exploit local scientific knowledge as well as harness and apply new technologies. The next section of this paper is focused on the kinds of scientific and technological opportunities and challenges faced by developing countries to improve public health.

1.2 Scientific and technological Opportunities and Challenges

[11] See Report of Millennium Project Task Force 5 Working Group on Access to Essential Medicines.
[12] Bystrom, M. and Einarsson, P. (2001), 'TRIPS: Consequences for Developing Countries—Implications for Swedish Development Cooperation. SIDA, Stockholm.
[13] UN Millennium Project (2005), *Innovation: Applying Knowledge in Development*. Task Force on Science, Technology and Innovation.
[14] WHO (2000), *World Health Report 2000*. World Health Organization, Geneva.
[15] See for example Sachs, J. (2001), 'Tropical underdevelopment', Cambridge, MA. NBER Working Paper 8119.
[16] See for example Republic of the Gambia (2003), First National Millennium Development Goals Report, and reports from Ghana, Kenya and Tanzania.

The discovery and application of new scientific knowledge and technologies for the diagnosis, prevention and treatment of diseases have expended the range of options to solve public health problems. Such scientific discoveries and technologies as recombinant vaccines, molecular diagnostics, recombinant therapeutic proteins, nutritionally enriched genetically modified, and combinatorial chemistry offer new opportunities to address health challenges in developing countries.[17] In a recent article Juma and Yee-Cheong document benefits that genomics offer for global health. "Recombinant vaccines can play an important part in improving global health. Genetic engineering has made it possible to produce single proteins of the pathogen in non-pathogenic microorganisms. This approach produces safer vaccines, since the individual proteins cannot cause the disease…..Closely related to advances in vaccines are improved methods of vaccine and drug delivery." [18]

Genomics is making it possible for scientists and companies to identify genes that are linked to particular diseases. They are able to develop genetic tests that can facilitate prevention of certain illnesses. This science has also advanced drug development in very profound ways. Combined with advances in imaging technology and sensors, medical practitioners will be able to use genomic approaches to diagnose many neoplastic diseases and offer early treatment. The completion of the mapping of the malaria parasite genome and the genomes of bacteria and many other parasitic organisms will pave the way for the development of vaccines and other control measures for many of diseases in developing countries.

In its 2004 report entitled *Innovation or Stagnation*, the US Federal Food and Drug Administration (FDA) pointed to indications that "medical product development is no longer able to keep pace with basic scientific development". It concluded that "only a concerted effort to apply the new biomedical science to medical product development will succeed in modernizing the critical path".[19]

Advances in information and communications technologies are affecting the way science is conducted. These technologies are making it relatively easy to harness and apply science in such fields as in genomics and proteomics. They are having enormous impact on the development of new drugs, vaccines, diagnostics and other products such as contraceptives. These advances hold promise of meeting health priorities of developing countries.

Some developing countries are already reaping benefits of biotechnology. For example, Cuba has deployed biotechnology to develop two vaccines: Meningitis B vaccine and hepatitis B vaccine. The meningitis B vaccine is effective and exported to many countries. Despite the embargo, the US has made an exception and has agreed to import this vaccine. Cuba generates more than US$ 100 million annually from the sale of vaccines. More than 97% of Cuba's children and adult population have been vaccinated and acquired immunity against meningitis. India is another developing

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[17] Daar, A.S., Thorsteinsdottir, H., Martin, D.M., Smith, A.C., Nast, S., and Singer, P.A. (2002), *Top 10 Biotechnologies for Improving Health in Developing Countries*. Joint Centre for Bioethics, University of Toronto, Canada.

[18] Juma, C. and Yee-Cheong, L. (2005), 'Reinventing global health: the role of science, technology and innovation' p 1105 in www.thelancet.com Vol. 365 March 19, 2005.

[19] FDA (2004) Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Technologies. US Federal Food and Drug Administration (FDA), DHHS.

country that is exploiting the potential of biotechnology and genomics. In 1997 one of its companies, Shantha Bioethics, launched a recombinant hepatitis B vaccine.

Most developing countries lack scientific and technological capacities for drug development. They are highly dependent on products manufactured by companies of developed countries. In an indicative assessment of R&D capability and capacity, Olliaro and Navaratnam show that only a few developing countries possess the necessary capability to engage in scientific research and in the development of medicines or manufacture of pharmaceuticals.[20] Based on a survey conducted by the New Partnership for Africa's Development, in Africa it is South Africa, Egypt, and Kenya that possess capability to conduct drugs research and engage in some productive activities. Of these South Africa and Egypt are the ones with local companies engaged in some pharmaceutical manufacturing activities. According to Olliaro and Navaratnam, Algeria has reported capability to produce pharmaceutical products as oral liquids, tablets, capsules and ointments. This potential is not yet translated into capacity because of the absence of a strong industrial production base.[21]

Olliaro and Navaratnam's survey of health R&D shows that the following developing countries have the necessary capacity for synthetic chemistry: India, Malaysia, Thailand, Brazil and South Africa. It also shows that "medium throughput screening is available in Thailand for anti-malaria, anti-TB and other antibacterials and antivirals, principally in two institutions. Four institutions in South Africa have screening capabilities for anti-TB and anti-malarial activity. There is no information on the availability of systematic screening capacities in the rest of Africa. ….India has extensive screening capacity, especially with respect to natural products. Several institutes in Brazil also have screening capacities, but again, these are fragmentary and at the low throughput scale, except one private facility. Algeria reports that there is capacity for primary, secondary, and tertiary screening of medicinal plants."[22]

In a recent study, Morel *et al* (2005) observe that "developing countries themselves are building innovative capacity for new health technologies, products and services. Collectively they already invest at least $2.5 billion per year in health research. … Public and private sectors in some developing countries are also working to build innovative capacities through the establishment of IP management systems, drug and vaccine manufacturing facilities, and regulatory capabilities."[23] The study also shows that India, China, Brazil, South Africa, Thailand, Argentina, Malaysia, Mexico and Indonesia are among the top 25 countries in the world in terms of innovative capacity measured or analyzed based on number of US patents issued where at least one inventor is from the subject country. It uses citations of published articles as another proxy indicator of health innovative capacity to show that Brazil, China, India and South Africa have numerical and percent increases in the number of papers among 1% of most highly cited papers in the world.

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[20] Olliaro, P. and Navaratnam, V. (2002), 'Technical Cooperative Networks in Developing Countries for Sustainable Access to Affordable, Adapted Medicines'. MSF/DND Working Group.
[21] Olliaro and Navaratnam (2002).
[22] Olliaro and Navaratnam (2002).
[23] Morel, C. et al (2005), 'Health Innovation in Developing Countries to Address Diseases of the Poor', p. 3 in *Innovation Strategy Today* 1(1):1-15. www.biodevelopments.org/innovation/index.htm

Another survey, Paraje, G. et al (2005), shows that countries with the highest burden of disease do not make significant contributions to the global pool of health science. "Scientific publications on health topics [are] disproportionately distributed and highly concentrated among the world's richest counties…The low share of publications (less than 2% of the total) indexed from low-income (LI) countries declined by about 10%. Only one-fifth of the total for these 63 countries is produced in Sub-Saharan Africa (46 countries), whereas the bulk was mainly from Southeast Asia. India contributed 73% of the research outputs of LI countries in 2001, up from 66% in 1992."[24] Brazil, China and India are among the top 20 producers of highly rated and indexed publications on health.

The impressive trends in citations and patents in the few developing countries mentioned above is likely to be a result of investments in health R&D, and long-term training in specific science and engineering fields. These countries' increasing proportion of their contribution to global health scientific outputs can, to a large measure, be attributed to specific changes in their health policies to integrate scientific research and innovation, increased funding to health research, and more investments in training medical doctors, practitioners and health scientists in various areas. They have also increased financial support to health laboratories.

Despite these trends, a majority of developing countries are not improving their scientific and technological capacities to address health challenges. Profiles of health research capacities of a number of developing countries have been prepared by the Council on Health Research for Development (COHRED) Task Force on Essential National Health Research. These cover Ghana, Jamaica, Tanzania, Uganda, Brazil and South Africa among other countries. Jamaica's profile of health research between 1991 and 1995 showed that of the 43 organisations and research groups surveyed, 29 met the criterion of at least one peer reviewed publication. Funding opportunities as opposed to national health priorities are largely determined research foci. According the profile, "[o]n the whole local research groups appear to be small, vulnerable, under-funded and deficient in basic equipment as well as trained and experienced researchers and support staff. These are compelling reasons for health researchers to come together to tackle common problems, promote collaboration and forge a joint strategy to strengthen health research capability in Jamaica"[25]

Another capacity assessment conducted for COHRED in 2000 shows that Pakistan has accorded health research and related human resource development low priority. The assessment showed that the country had only 966 health research scientists and only 42 of these had doctorate degrees.[26] Pakistan's ministries are not well coordinated and structured with the Ministry of Science and Technology (MoST) having limited interaction with the Ministry of Public Health and the Pakistan Research Council.

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[24] Paraje, G. et. al. (2005), 'Increasing International Gaps in Health-Related Publications' p. 959

[25] Figueroa, P. and Henry-Lee, A. (1998), 'A Profile of Health Research in Jamaica 1991-1995'. West Indian Med Journal, Vol. 47(3)

[26] Akhter, T. et. al. (2000), 'Capacity development for health research in Pakistan: evaluating a decade of efforts'. Report to the Council for Health Research for Development (COHRED) and the Provincial Health Services Academy (PHSA) of Pakistan.

The United Nations Development Programme (UNDP) *Human Development Report 2001* shows that countries with leading health crises and challenges are also characterized by low technology achievement index. They have low capacity to adopt and use existing technologies.[27] The last 12 countries (all African) on the Human Development Index (HDI) ranking of 2001 are characterized by low expenditure on R&D, high cases of malaria and other diseases, and low technology absorptive capacity. For example Rwanda with 20,310 malaria cases out of every 100,000 people, has approximately only 35 scientists and engineers per 100,000 people. On the other hand China with 2 malaria cases out of 100,000 has approximately 450 scientists and engineers per 100,000 people. Uganda with 142 tuberculosis cases per 100,000 people reported in 1998 was spending only 0.6 percent of its Gross National Product (GNP) on R&D while Norway with only 8 tuberculosis cases out of every 100,000 in the same year was spending 1.7 percent of its GNP on R&D.[28]

A number of factors account for low levels of scientific and technological capacities in developing countries. *First*, many of these countries have not reviewed and revised their health policies to focus on the role of science and technology. Their policies treat science and technology as exogenous variables to the improvement of health.

Secondly, developing countries have devoted considerably low, and in many cases declining, funding to health R&D. Most of them spend less than 0.5 percent of their Gross Domestic Product (GDP) on health R&D. The low and declining expenditure on health R&D is a manifestation of the low priority that countries have given to science and technology. Private sector's contribution to public health R&D is low or non-existent in many of these countries. Most governments have not instituted specific policy and legal measures to attract private investment in public health R&D.

Thirdly, generally there are weak links between public health R&D institutions and private industry in many developing countries. Research results of public R&D activities do not often get accessed and used by pharmaceutical and medical industries. In many cases there is mismatch between health R&D activities and industrial development goals and strategies designed and implemented by the countries.

Scientific and technological capacity for improving public health in developing has largely been neglected by governments, development assistance agencies and private sector. There is limited knowledge of and information on developing countries' scientific and technological capacities for health. Most of the studies of scientific and technological capacities for national economic change and development have ignored or given very limited attention to health dimensions. "Despite at least a decade of explicit effort to link development, health, and research worldwide, we find little inquiry into the role of scientific (and technological) capacity."[29]

[27] UNDP (2001), *Human Development Report 2001, Making New Technologies Work for Human Development*. United Nations Development Programme, New York.
[28] This figures are drawn from UNDP (2001), *Human Development Report 2001, Making New Technologies Work for Human Development*. United Nations Development Programme, New York.
[29] Freeman, P. and Miller, M. (2001), 'Scientific Capacity Building to Improve Population Health:

Efforts to build and/or strengthen abilities of developing countries to improve public health will need to be informed by or based on assessments of national systems of health research and innovation. The next section proposes a generic framework for assessing national scientific and technological capacities. It proposes the concept of 'national health innovation systems' as an organizing conceptual framework for capacity assessment and building.

2. CONCEPTUAL ISSUES AND FRAMEWORK FOR CAPACITY BUILDING

2.1 Scientific and technological capacity defined

Scientific and technological capacity can generally be defined to have at least three core components—skills or expertise, context, and institutions. The first—skills/expertise—are embodied in people. They are of a wide range and they are to be configured based on specific problems to be solved. The second component of capacity—institutions—are rules, norms and organizations. Rules and norms are often articulated as policies of different kinds: health, industrial, science and technology, and economic policies. Organizations whether local communities or national R&D centres are the ones that mobilize and use the skills/expertise as well as design and implement policies. It is not the mere existence of health R&D organizations that constitute national capacity but how each of these agencies are linked to and articulate with other organizations in the country.

The third component of capacity is the context in which skills/expertise and institutions (policies and organizations) evolve and operate. The context comprises of the overall political, economic, social-cultural, general infrastructure and resource endowment conditions. Context determines or influences whether and how a country's skills and institutions are created, mobilized and utilized.

Scientific and technological capacity for health cannot, thus, be reduced to equipment, funding and number of health scientists and technicians. It is the configuration of skills, policies, organizations, non-human resources, and overall context to generate, procure and apply scientific knowledge and related technological innovations to identify and solve specific health problems. The capacity is built through interactive processes of creating, mobilizing, using, enhancing or upgrading, and converting skills/expertise, institutions and contexts. It is not about isolated activities or projects.

Freeman and Miller (2001) define scientific capacity for health to encompass "biomedical sciences from fundamental laboratory studies to the development of preventive and therapeutic products and their evaluation; epidemiology, health services and operations research; policy research; all applying economics, social, and behavioural sciences."[30] Though leaving out physical sciences and engineering, this definition recognizes social and economic contexts and policies as part of capacity.

2.2 Health Innovation Systems: A Framework for Capacity Assessment

[30] Freeman, P. and Miller, M. (2001), 'Scientific Capacity Building to Improve Population Health, p. 6.

The concept of 'national systems of innovation' was developed by a number of writers in the 1980s to improve understanding of why some countries are technologically advanced than others. It had by then become clear that the relative success of some countries in generating scientific knowledge and technological innovations and applying these to economic production could not be simply explained in terms of traditional economic policies but much more by a range of institutional arrangements that mobilized skills, knowledge and the quality of science, technology and innovation policies.

In its early form, the national innovation system was equated to agencies that are directly concerned with science and technology, such as national laboratories and university science departments. With time the list of actors has been extended to include private sector organizations, consumer organizations, policy-making bodies, and programmes.[31] More recently emphasis has been placed on inter-institutional linkages and information flows among and between various actors. Where the interactions are established and dynamic, technological innovation takes place. Conversely, where system components are compartmentalized and isolated from one another, the result is that relevant research bodies are not productive.

The concept of a national innovation system goes well beyond the mere establishment of necessary organizations. Rather, it is concerned also with policy conditions and institutional arrangements, including linkages, for stimulating creativity. The notion of a health innovation system is thus more than just the sum of R&D institutions, health care organizations and medical scientists and practitioners, but includes also the policy regime that determine how well there are mutual interactions among various actors. It is a system with changing actors, connections and interactions. "[P]erhaps the most important lesson that can be drawn from a National System of Innovation is a view of the whole as the result of a very complex and dynamic interplay of connecting parts such as institutions, culture, legal and regulatory framework, trade and policies….by identifying and understanding the inner interactions of the components it may be possible to improve the whole."[32] It should be clear, therefore, that the institutional context and how it is defined is central to the assessment of a country's scientific and technological capacity for improving health.

The relationship between institutions and development has become the subject of academic interest. There is a preponderance of theoretical and empirical research on the role that institutions play in promoting technological innovation and economic development. Some of this research deploys systems theory to examine how institutions evolve, learn, change and interact to stimulate innovation and development.[33] They offer a rich theoretical ground for studying and assessing how countries build or accumulate scientific and technological capacities.

We adopt the systems approach to define a national health innovation system as the network of public and private institutions[34] whose interactions and activities generate and/or use scientific knowledge and produce as well as apply technologies to

[31] Oyeyinka, B. (2005), 'Systems of Innovation and Underdevelopment: An Institutional Perspective'. United Nations University (UNU) Institute for New Technologies, Discussion Paper.
[32] Rangel-Aldao, R. (2005) 'Innovation, Complexity, Networks and Health'. Draft working Paper.
[33] See for example Lundvall, 1992, Freeman, 1987
[34] We define institutions to encompass policies, rules and organizations

solve specific health problems. Such interactions may be technical, commercial, legal, social and financial, inasmuch as the goal of the interactions is the development and application of health sciences and technologies. The systems approach treats innovation as a social process that is determined by institutional arrangements in which it evolves.

The systems approach enables capacity assessment exercises to go beyond measuring the amount of R&D done in a country. It brings together such important factors as the ways in which available resources (including skills and information) are organized at both institutional and national levels. Within this context information exchange and flow are highly important variables.

The elements of a national health innovation system—the persons or individuals, organizations, and programmes and policies—are to be found in most developing countries. What distinguishes the successful from the unsuccessful national health innovation system is its capacity to promote constructive interactions among these many elements to overcome lack of policy coherence, deep fragmentation of research and innovation effort, and often enormous inefficiencies in the allocation and use of resources. The creation of this capacity has to be consciously conducted by the individuals and organizations within a country—it is cannot be created by decree from the outside. Equally, a national health innovation system of innovation can be at its most useful in a country which has some clearly-articulated and shared goals of improving health.

In summary, a national health innovation system can be perceived of as a set of functioning organizations and policies which interact constructively in the pursuit of a common set of health goals, and which stimulate the introduction of innovations to reduce the burden of disease and improve public health. In the developed countries, and in a growing number of developing ones, policy makers have found that the concept of a “national system of innovation” provides a useful framework for policy formulation and managing institutional change since it makes explicit the many different kinds of inputs and actors that are necessary to stimulate and sustain economic change and national development. Such a conceptual approach is ideal for assessing nations’ of scientific and technological capacities as it allows policy-makers and other stakeholders to understand the dimensions and performance of the health policies and institutions in their country and to point out ways in which these can be made more effective and efficient.

The next section focuses on health innovation systems, with emphasis on institutions supporting technical advances for the discovery and production of medicines in innovative developing countries—those that have some resemblance of national health innovation systems.

3. Health Innovation Systems In Developing Countries: Some Illustrative Cases

The development of medical processes and products is generally science and technology intensive. Few developing countries have the necessarily capacities to conduct research and develop drugs and medical processes for neglected diseases. There are few public institutions dedicated to drug research and production in developing countries. In Africa, it is perhaps South Africa that has demonstrated scientific and technological capacities for drug research and development. Other developing countries with institutions and programmes dedicated drug research and development include India, Brazil and China.

South Africa has a relatively well endowed institutional landscape and policies for health research and development. In 1996 it adopted a comprehensive science and technology policy regime that is conceptually based on the national innovation system approach. This regime—the 1996 White Paper on Science and Technology—lays out a wide range of policy and institutional measures for increasing investment in health R&D, improving interactions among various actors (particularly public health R&D and pharmaceutical companies) and developing a new cadre of scientists.

The country's agencies or organizations for health research and innovation include the Medical Research Council (MRC), the South African Institute for Medical Research (SAIMR), the National Institute for Virology (NIV) and the Council for Scientific and Industrial Research (CSIR). In addition, its universities have specialized faculties or colleges dedicated to health research. These institutions command a relatively rich skills and financial base, at least compared to those of most other African countries.

The MRC has a strong scientific base, mainly in its research units situated at a number of universities in the country. Its mission is to make a major contribution to health research and promote the translation of the research into public benefit through technology development and transfer. The MRC Innovation Centre (IC), previously known as the Technology Development and Transfer Group, is responsible for ensuring that the organization's research is translated into tangible health products and services.

The CSIR has established the National Advanced Chemical Manufacturing Centre (ACMC) as specific programme for generic pharmaceutical manufacturing at its Bio/Chemtek facilities. Specific pharmaceutical products already produced by the programme include:

- *(S)*-Naproxen, (non steroidal anti-inflammatory)
    - *Technology package developed, and technology transferred for commercial manufacture*
        - *(US Patent 5750764 1998, PCT Patent WO 97/19048, 1997)*
- Nevirapine (reverse transcriptase inhibitor)
    - *Process developed for Imbiza plant*
- P-Aminophenol, precursor to Paracetamol (analgesic).
    - *2-step process developed from nitrobenzene or phenol*
- Trimethoprim (antibacterial)
    - *Process developed from 3,4,5 trimethoxy benzaldehyde*
- (D)-Hydroxyphenylglycine (Penicillin Side chains)
    - *Efficient biocatalysed process developed*
- *(R,S)*-Ketoprofen (non steroidal anti-inflammatory)
    - Process developed using novel arylation technology

- Sumatriptan (Anti-migraine)

The African Centre for Gene Technologies (ACGT) is an another initiative started by the CSIR in collaboration with the University of Pretoria, but with increasing involvement by other organisations, to create a world-class platform in gene technologies, with particular focus on gene and genome analysis and applications to health. The ACGT provides an integrating role for activities in genomics, proteomics, structural biology and bioinformatics. Its outputs will include international patents with commercialisation potential, and biotechnology start-up companies, as well as students trained in the most modern technologies and top quality research publications.

South Africa is playing a major role in the development of vaccines, mainly for HIV/AIDS. The South Africa AIDS Vaccine Initiatives (SAAVI) is a mechanism for mobilizing the country's scientific and technological capabilities from the science councils, industry and universities. It brings together the University of Stellenbosch, the MRC, the University of Cape Town and the National Institute for Communicable Diseases as well as such key international partners as the University of North Carolina and the International AIDS Vaccine Initiative. The SAAVI has generated six candidate vaccines that are now under evaluation at the University of Cape Town.

The pharmaceutical industry is active in South Africa's health innovation system. There are about 96 pharmaceutical companies in the country.[35] Multinationals spend between US$ 12 million to US$ 15 million per year on drug trials.[36] However, the industry it is not really involved in new drug discovery activities. Most of its research is conducted abroad in the parent companies. Some local companies are manufacturing cheap antiretroviral drugs through licensing agreement. For example Aspen Pharmacare has a licensing agreement with GlaxoSmithKline to manufacture Combivir in the country. GlaxoSmithKline waved the right to a royalty fee.

In addition to the institutional arrangements, there is a range of policy instruments for health research and innovation. These include the 1996 White Paper on Science and Technology, intellectual property protection legal (specifically Act 101 of 1965 establishing the South African Patent and Trademark Office (SAPTO), the Medicines and Related Substances Control Act, and the National Biotechnology Strategy.

Egypt is another African country with a relatively strong health research and innovation base. With "an extensive scientific and technological infrastructure, largely comprising of 33 universities with 22 affiliated research centers, together with another 81 research centers affiliated with 16 government ministries" the country is engaged in health research and product development. It has a number of local and multinational pharmaceutical companies that are exploiting scientific research. In the area of health biotechnology, for example, it has produced diagnostics and treatments for hepatitis B and C.[37] The country is able to produce pharmaceutical products for at least 90% of its domestic use and imports a relatively small portion, mainly of technology intensive products.

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[35] http://legacy.hst.org.za/sahr/99/chap27.htm
[36] http://legacy.hst.org.za/sahr/99/chap10.htm
[37] Abdelgafar, B. et. al. 'The emergence of Egyptian biotechnology from generics' p. 25-30 in *Nature Biotechnology* Vol 22 Supplement December 2004.

Kenya has scientific potential to grow a health innovation system. The University of Nairobi and the Kenya Medical Research Institute (KEMRI) are the main public R&D institutions with tract record for scientific research on health issues. KEMRI has entered into research partnerships with a number leading international organizations. It has well-developed laboratories that perform a range of standard diagnostic procedures (serology, hematology, microscopy) for malaria and HIV. The University of Nairobi has a relatively good number of scientists engaged in teaching and some research. It has forged linked to medical institutes abroad.

However, the country's scientific potential is untapped because of a wide of policy and institutional failures. These include the absence of local companies with incentives to exploit local science, weak links between KEMRI and industry, and to a large extent absence of policies to stimulate health innovations. The 2004 agreement between GlaxoSmithKline (UK) and Cosmos Ltd (Kenya) for local manufacturing of three key generic drugs for HIV/AIDS offers the country an opportunity to bring its health research institutes closer to industry and for the more local companies to emerge. But the government has not focused on this opportunity to ensure that national R&D institutions (e.g. KEMRI and the universities) are directly involved. The manufacturing of generic drugs agreements are being brooked by the Ministry of Trade and Industry with minimal, if any, participation of the Ministry of health and the Ministry of Education, Science and Technology. This lack of institutional linkages may be a manifestation of the absence of health innovation system in Kenya.

Outside Africa, *India* has a dynamic pharmaceutical industry with links to an extensive public scientific research infrastructure. In 1994 it spent at least 0.81 of its Gross National Product on R&D, with a significant portion targeting health sciences.[38] It has 21 national research institutes and more than 1.5 million scientists dedicated health research. These are coordinated by the Indian Council of Medical Research. In terms of health innovation policy, the Indian government is experimenting with a range of policies to provide incentives to firms or companies to conduct drug research and development. Specific policies include provision of venture capital for start-up firms, no excise duty on importation of equipment, tax free profits, no price control on exports, and high tariff protection.

There are more than 30 companies involved drugs and pharmaceutical development in India. In 2003 more than 400 different drugs were produced by Indian companies. The export product range include Antibiotics, Anti-TB drugs, Analgesics/Antipyretics and few drug intermediates have been able to make an organised and systematic break through in the international market in terms of high growth rate on a reasonably high value turnover.

Brazil is another developing country with a relatively established health innovation system and a growing pharmaceutical R&D base. It has at least 450 companies engaged in various activities relating to pharmaceutical product development. The country's Ministry of Health coordinates a range of laboratories for R&D. There are at least 18 laboratories with a growing pharmaceutical productive

[38] http://forums.techarena.in/showthread.php

capacity estimated at 11 billion units per year in Brazil.[39] Its intellectual property legislation provides for the development and sell of generic drugs. It aims at ensuring that the public has easy access to medicines, particularly for chronic diseases. By 2004 1,033 generic drugs had been registered in the country.[40]

The country has also accumulated scientific and technological capacity for vaccine production. The National Programme for Self-Sufficiency in Immunobiologicals (PASNI) established in 1985 has been instrumental in promoting training and research for vaccine production. "Data from Capes and the IBGE attest that in 2000, private companies in Brazil employed 4,000 employees with a Master's degree or doctorate. Universities and research institutes, state-owned laboratories and Non-Governmental Organizations (NGOs) employed 42,000 researchers."[41]

A key component of Brazil health innovation system is the policy regime that the government has developed and is implementing. The regime includes policies for drug research and development. In 1998, Brazil's Ministry of Health developed and adopted the "National Drug Policy" that lays out measures, priorities and activities health-related regulation of medicines, the re-orientation of pharmaceutical services, and promotion of the rational use of drugs, scientific and technological development, the promotion and production of pharmaceuticals. The policy also outlines specific actions for increasing the number of health scientists, technicians and practitioners in the country.

To improve inter-institutional linkages, the Government of Brazil has initiated processes to ensure that the Ministry of Health works closely with the Ministry of Science and Technology. It has organized national conferences on science, technology and innovation in health to bring together science and technology policy-makers and those for health. These conferences have focused on identifying and instituting measures to strengthen the link between scientific research and activities to benefit public health in Brazil.

In summary, a number of developing countries are growing or creating health innovation systems. This is demonstrated by the emergence and activities of their dynamic public and private sector institutions, the nature and range of health products (particularly drugs), and the kinds of policies they are applying to stimulate knowledge production and technological innovations. However, there are very few developing countries with health innovative capacity. Their capacities for harnessing and applying science and technology need to be strengthened.

The next section examines how regional and international collaboration can contribute to the building of health innovation systems—scientific and technological capacity building—in developing countries.

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[39] MIHR (2005), 'Innovation in Developing Countries to Meet Health Needs: Experiences of China, Brazil, South Africa and India'. Centre for the Management of Intellectual Property in Health Research and Development, WHO Ref. CIPIH Study 10d.
[40] MIHR (2005), 'Innovation in Developing Countries to Meet Health Needs: Experiences of China, Brazil, South Africa and India'. Centre for the Management of Intellectual Property in Health Research and Development, WHO Ref. CIPIH Study 10d.
[41] MIHR (2005), p. 89.

4. Regional and International Health Innovation Activities

4.1 Importance of Regional and International Collaboration

Regional and international collaboration in science and technology generally and health sciences in particular is increasing in intensity and complexity. Recent studies show that collaboration in health related scientific and technological activities has increased between some developed and developing countries.[42] The growth in collaboration is stimulated by a variety of factors, including globalization and increasing recognition of benefits of such cooperation.

New information and communications technologies are making it relatively easy and in some cases cheaper for scientific and technological information to be exchanged across countries and regions. These technologies have radically changed ways by which scientists and scientific institutions create knowledge and search as well as exchange information. The frequency and ease of information exchange have improved considerably, at least in the past decade or so. This has led to new forms of organizations. Witness the emergence and spread of 'e-laboratories', 'e-libraries', and 'virtual universities'. Scientists in one continent can now conduct research and share their results with their counterparts in another continent in real time.

In addition to these developments, increasing international recognition that such health challenges as HIV/AIDS and SARS are global in nature and require global action has stimulated more attention to the role of cooperation in health sciences and technology. Regional and international treaties or agreements on such issues as trade and intellectual property contain provisions aimed at promoting collaboration in R&D.

Collaboration in health R&D and related technological innovation can take various forms, including joint science projects, sharing of information, conferences, building and sharing joint laboratories, setting common standards for R&D, and exchange of expertise. Its advantages for developing countries include:

- (a) access to new knowledge, foreign skills and training opportunities that may not be available at the national level;
- (b) access to large and often expensive research facilities, including laboratories and libraries
- (c) avoiding the costs of duplication of research;
- (d) enrichment of political and social relations between countries;
- (e) opportunities to establish multidisciplinary research activities and teams
- (f) favourable basis for international funding; and
- (g) building or strengthening domestic R&D institutions.

On the whole, regional and international collaboration provides for pulling together resources and activities of different nations to benefit one another in ways

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[42] See for example Advisory Council on Science and Technology (2000) *Reaching Out: Canada, International Science and Technology, and the Knowledge-Based Economy*. Report of the Expert Panel on Canada's Role in International Science and Technology, also see Wagner, C. *et. al*. 2000. *International Cooperation in Research and Development: An Update to an Inventory of U.S. Government Spending*. RAND, Santa Monica, CA.

that the whole becomes greater than the sum of parts. The other factor that supports collaboration is economy of scale. By pooling their resources, countries can build bigger and effective research and innovation programmes than they could individual using their own resources.

However, regional and international collaboration are not costless and automatic processes. They have to be based on mutually agreed terms and clear understanding of differentiated capabilities of parties involved. Moreover, if not carefully configured they could undermine individual countries' efforts to target and address their health priorities. Most if not all countries support research in those areas that are of priority or immediate concern to them. Many believe that they should invest in those research and innovation programmes that make their national industries and economies more competitive. In addition, programmes for regional and international collaboration tend to be costly in terms of coordination. These concerns can be well addressed if information on the priorities of participating countries and their institutions are clearly articulated, differentiated capabilities identified, and common norms and rules established.

There are numerous initiatives for regional and international cooperation in health sciences and technology. These include programmes such as the Human Genome Project (HGP), Grand Challenges in Global Health Initiative funded by the Bill Gates Foundation, the Global Forum for Health Research and the New Partnership for Africa's Development (NEPAD) Health Strategy and the NEPAD Biosciences Initiative. Let us consider the emerging NEPAD strategy and initiative.

4.2 Regional Collaboration for Health Innovation: NEPAD's Strategy and Initiative

African countries have explicitly recognized that reducing the disease burden and, more specifically, fighting HIV/AIDS, malaria and tuberculosis will require increased investments in R&D. They have designed and adopted a NEPAD Health Strategy that puts emphasis on the role of health sciences and innovations. In addition, African countries have developed a continental science and technology framework for strengthening their institutions for R&D and innovation.

The NEPAD science and technology framework is founded on the recognition of benefits of regional collaboration in R&D and technology development. It focuses on promoting collective efforts to establish a network of centres of excellence in biosciences for health and other areas of human development. Already a NEPAD Biosciences Network has been launched. It has four regional hubs and a growing number of nodes dedicated to mobilizing Africa's scarce scientific and technical infrastructure, expertise, financial resources, and international funding to conduct cutting-edge scientific research and generate innovations in agriculture, environment and health sectors. The network has sub-networks: Biosciences East and Central Africa (BECA), Southern Africa Biosciences (SAB), West Africa Biosciences (WAB) and North Africa Biosciences (NAB).

Of the four sub-networks, SAB and NAB have programmes and projects that explicitly focus on human health. These are founded on the view that the contribution of the large pharmaceutical companies to new therapeutic agents for conditions which can be considered diseases of the poor in Africa and other developing regions of the world will decline dramatically in the next decade or so. With the resistance to existing therapies becoming endemic, it is of critical importance that research into alternative treatments be carried out. SAB and NAB will mobilize expertise, physical infrastructure (laboratories) and funding to conduct research in such areas as structural biology, bioprospecting, medicinal chemistry, and drug screening and development.

A particular challenge associated with HIV/AIDS is the treatment of Opportunistic Infections (OI) suffered by virtually all people at different stages of progression of the disease. The treatment of people infected with the disease using conventional therapeutic interventions is beyond the reach of most African countries because of the cost of imported medicines. SAB is focused on the development of a lead for an effective, safe and affordable herbal treatment(s) for OI suffered by people living with HIV/AIDS.

North Africa has an extensive network of universities and research institutions employing thousands of scientists in health related areas. Unfortunately productivity in terms of innovation and product development is low and does not match the existing institutional and human resources. NAB's hub in Egypt offers the opportunity for scientists in North Africa working in diverse areas of medical technologies to combine and coordinate their efforts in genomics and other areas to lay down the foundation for implementing a modern and advanced health care delivery system developing therapies and management systems for prevalent diseases. NAB is being designed with projects to carry out population genetic studies to identify correlations between genes and diseases as well as the molecular basis of heterogeneity in drug response in populations of North Africa.

The NEPAB Biosciences Initiative is expected to collaborate and integrate its activities with international networks for the purpose of exchanging information on comparative genomic studies and training in advanced methodologies. It will establish links to pharmaceutical companies. It has potential to contribute to the reduction of disease burden and strengthening of health innovation systems in Africa if it is well configured and targeted at specific diseases. It needs to involve private sector with capability to engage in bioengineering. On the whole, it can make a difference in stimulating the emergence of national health innovation systems.

To ensure that the biosciences network builds health innovation capacity, there are efforts to ensure that the hubs have explicit links to industry. Industry is represented on the steering committees of each of the hubs and workshops have been held in Egypt and South Africa to design business plans for establishing health science parks. In addition to these, the NEPAD is supporting each of the sub-networks to prepare intellectual property protection guidelines. BECA has already adopted IPR guidelines and SAB considering a draft from its steering committee.

Other regional programmes that have potential to contribute to the building of health innovation systems in Africa include the recently launched African Programme for Health Innovation (APHI). APHI is an initiative of MIHR and the South African Medical Research Council (MRC) supported by the UK Department for International Development (DFID). Its overall aim is to build human resources for managing health technology. The programme puts emphasis on strengthening scientific networks. APHI offers short courses on topics such as intellectual property protection, public-private partnerships, and technology transfer.

4.3 International collaboration for health R&D: Some Examples

There are numerous programmes for international collaboration that is aimed at building scientific and technological capacities of developing countries to address their health challenges. The WHO Special Programme for Research and Training in Tropical Diseases (TDR), Europe-Developing Countries Clinical Trials Partnership (EDCTP) and WHO Initiative for Vaccine Research are examples of programmes that are dedicated to health R&D and technological innovation. Of these the TDR has a relatively long history and is well-known in developing countries' health R&D circles.

The TDR began operations in 1976. It is sponsored by the WHO, the United Nations Development Programme (UNDP) and the World Bank. The Programme focuses on eight tropical diseases through R&D directly and through capacity-building. Its main elements of capacity-building include grants for research training and for institution-strengthening. By 2000 TDR had made financial investment of more than US$100 million.

To ensure that research is translated into products, the TDR has the Product Research and Development unit (PRD). PRD aims at promoting the development and registration of new drugs for neglected tropical diseases. TDR/PRD funds projects at all stages of drug discovery and development, generally working in close collaboration with academic institutions and/or pharmaceutical companies

In the recent past TDR has began to put emphasis on establishing networks of organizations, forming partnerships across countries, across scientific disciplines and across political boundaries. A key limitation of the TDR is the weak links to local companies and universities in developing countries. Its efforts are bridging the research and local production gap have largely remained on paper. The 1998 third external review included the following as one of two "mandatory" recommendations: "more focused strategies are needed to strengthen the research capacity of countries and regions bearing the heaviest burden of endemic tropical diseases, with an increasing focus on least developed countries"[43] By 2000, TDR had dedicated 33% of its overall funding to research capacity-building in Least Developed Countries. However, its evaluation does not provide evidence on whether the global burden of disease for the conditions in the TDR portfolio has diminished incrementally since the programme was initiated almost 30 years ago.

TDR is a good example of sustained collaborative support from three agencies focused on specific disease conditions of developing countries. Its capacity-building strategy has concentrated primarily on individuals and institutions in disease-specific research. A major gap is the absence of attention to improving overall health R&D

[43] TDR (1998), 'Final report: third external review'. United Nations Development Programme; World Bank; World Health Organization; TDR, Geneva, Switzerland. TDR /JCB 921) 98.5.

policies and stimulating linkages between science and technology policies and those for health. The programme as a whole offers a good foundation for launching a global effort to building health innovation systems in developing countries.

The Grand Challenges in Global Health initiative, is another a major international effort that is aimed at stimulating the building of national and global capacities for scientific breakthroughs against diseases that kill millions of people in developing countries. The initiative is supported by a $450 million commitment from the Bill and Melinda Gates Foundation, as well as two new funding commitments: $27.1 million from the Wellcome Trust, and $4.5 million from the Canadian Institutes of Health Research (CIHR). It has provided more than $430 million for a broad range of innovative research projects involving scientists in 33 countries. The ultimate goal of the initiative is to create health technologies that are effective, inexpensive to produce, easy to distribute, and simple to use in developing countries.

It is a good example of public-private partnerships to advance capacity building to help apply innovation in science and technology to the greatest health problems of the developing world. The priorities that the initiative focuses on were identified though consultative processes involving scientists, industry and policy-makers. The priorities include developing improved childhood vaccines that do not require refrigeration, needles; studying the immune system to guide the development of new vaccines, including vaccines to prevent malaria, tuberculosis, and HIV; and developing new ways of preventing insects from transmitting diseases such as malaria.

5. Strategies for Building Health Innovation Systems

5.1 Overview

The above cases illustrate a growing determination by the international community to contribute to the strengthening of developing countries' scientific and technological capacities to address health challenges. However most of these efforts are concentrated on building the competencies of individuals and organizations. Of course, skilled individuals and equipped organizations are important and essential parts of health innovation systems, but in themselves they are not enough. The broader policy context (including stimulating linkages between organizations) in which individuals and institutions operate need more explicit attention.

Most of the capacity building investments are going into producing more scientists and equipping stronger research units with new laboratories. These are largely supply-driven efforts and yet advances in science and technology are being driven by demand for new drugs and processes. In many developing countries, policy-makers have not focused attention to demand for new knowledge through research. As a result, the countries make low investments in R&D. This leaves scientists with little incentive to remain in universities and research institutes; those who remain struggle hard to sustain their motivation for innovation. Supply-side strategies for capacity-building tend to distort investment decisions. Long-term strategies that are based on specific policy realities, needs and cultures of developing countries are required. Thus capacity building activities should be driven by specific needs of countries. They should be holistic and focused on creating or growing innovation systems. But formulating and adopting will require dynamic and informed leadership in developing countries

5.2 Leadership for Health Sciences and Innovation

Given that health inequalities and the disease burden cannot be reduced with investments in science and technology, it is critical that national and international political leadership for health sciences and innovation is created. Such leadership forums or platforms as the United Nations General Assembly and the G8 have recognized the need to address health challenges of developing countries. But they have not given attention to the role that science and technology will play in achieving health related MDGs and generally reducing the disease burden.

The United Nations system and national cabinets need to become platforms for leadership for health sciences and innovations. The WHO Executive Board and the UN General Assembly need to do more than mobilize funding for training. They should provide space for exchange of ideas and experiences on why some few developing countries are growing health innovation systems while the majority are not. They should provide leadership for designing a comprehensive global strategy to build health innovation capacities of developing countries.

5.3 Assessing National Capacity Needs

The building of the capacity involves a variety of interrelated processes including the identification and/or creation as well as appropriate management of institutions for R&D, training and/or retraining of scientists, the training of policy makers (or decision-makers) in various policy and legal aspects of health science and technology, training in technology forecasting and assessment techniques, and mobilization of financial resources for R&D. In order to make informed decisions on the specific areas of capacity building it is crucial that developing countries be encouraged to undertake a *national health innovation surveys.* Such surveys would provide the necessary detail on areas that the countries should be investing in their capacity building efforts.

The conduct of national health surveys should be supported by such agencies as the United Nations Conference on Trade and Development (UNCTAD). UNCTAD has, over the past ten years or so, being conducting national systems of innovation reviews focusing on such sectors as agriculture. The methodological approach and some of the experiences generated during those reviews may be useful for the proposed national health innovation surveys.

5.3 Institutional Capacity-building

Many developing countries, particularly those of Africa, tend to spread thinly their limited financial and human resources across health research programmes and agencies. While many have recognized the importance of setting priorities and consolidating resources in a few those research institutions that have the potential of innovating, the countries have not established and applied strategies of identifying such institutions and ways of setting priorities. They continue to operate with isolated, competing and often scientifically weak research agencies. Some of these countries have stand-alone institutions established in anticipation of external funding rather than out of genuine interest in promoting health innovations.

Institution building for health innovation has largely taken place in a combination of research and product development institutions in India, China and Brazil, whereas in Africa there are no or very few public institutions dedicated to health products development. Much of the current research is being undertaken in older established health research institutions with limited engineering and productive capacities. Developing countries will thus need to review and undertake reform of their institutional arrangements in order to create innovation. Efforts such as Brazil’s to bring the ministry of health to work more closely with that for science and technology should be emulated by other countries.

There are many organizational and jurisdictional obstacles to the utilization of existing scientific expertise in developing countries. Where existing expertise does not reside in the institution that is charged health R&D it is often not drawn upon and utilized. Addressing this problem will require institutional reforms that enlarge administrative space and organizational outreach to recognize, mobilize and utilize the expertise.

5.4 Capacity-building for health innovation policy analysis

There is a general lack of studies on health innovation policies and systems. Little inquiry is conducted into the role of science and technology generally and particularly the building of scientific and technological capacity for improving health. Most of the science and technology policy studies have focused on technical change in industry and agriculture in developing countries. Analytical studies on technical change in health systems are required to inform policies and to shift attention to the role that science and technology can play in reducing the disease burden and strengthening health systems of the countries.

The development and commercial application of health innovation, particularly those associated with genetic engineering, present new challenges to those responsible for making public policies generally. New policy questions such as those on biosafety, access to genetic resources and transfer of biotechnology, distribution of benefits from biotechnology, privatization of scientific knowledge and intellectual property protection have to be addressed by decision-makers in developing countries. Many of the decision-makers in these countries do not however possess an adequate understanding of and information on the wide range of fairly complex policy issues. Building their understanding of the issues and skills to analyze health R&D policies is crucial to building national innovation systems. There are however relatively few centers with organized courses in health innovation policy. An international training programme on health innovation policy should be established by a consortium of such agencies as WHO, UNCTAD, Harvard University’s Centre for International Development and MHIR. The programme would aim at providing short and medium term training in selected key policy issues.

CONCLUSION

This paper provided an indicative assessment of scientific and technological capacity needs of developing countries to improve public health. It identified programmatic and institutional measures that are necessary to create health innovation capacities. Emphasis has placed on national, regional and international activities to build critical masses of skills, improve health policies, strengthen research institutions, and create agencies that generate health innovations in developing countries. The paper proposes the 'national innovation systems' approach as a good framework for designing capacity building activities in developing countries.

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