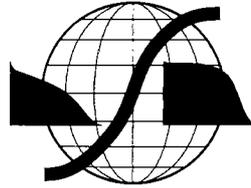


**THE ADVISORY COMMITTEE ON HEALTH RESEARCH**



# **A RESEARCH POLICY AGENDA FOR SCIENCE AND TECHNOLOGY**

**to support global health development**



**World Health Organization**

**Geneva**

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A Research Policy Agenda for Science and Technology to support  
Global Health Development  
WHO - Collaborating Center for Global Modeling of Health  
Perspectives, Günzburg, Germany on behalf of the Global Advisory  
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# Foreword

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This document is the development of a proposal by the Advisory Committee on Health Research (ACHR), summarised in a separate document (the "Synopsis"), for enhancing the contribution of Science and Technology to Global Health Development. It is the outcome of a series of developments arising from the "Technical Discussions" on Health Research, which took place at the World Health Assembly, in 1990. It also takes into account several "independent" studies and reports which have appeared over the last few years, providing important intellectual and methodological contributions.

The World Health Assembly, in its resolution WHA43.19 (1990) emphasised that all national health policies should be based on valid scientific evidence, and that such evidence required health research. It noted the world-wide mismatch between the burden of illness, which is overwhelmingly in the Third World, and investment in health research which is largely focused on problems of industrialised countries. This observation is compounded by the fact that many developing countries lack the scientific and institutional capacity to address their particular problems, especially in the critical fields of epidemiology, health policy, social sciences and other multidisciplinary areas.

The resolution invited Member States, the bilateral and multilateral development agencies as well as the research community, to intensify their co-operative efforts in health research, in policy analysis, and in strengthening scientific and technological infrastructures at national and international levels.

In addition, the Director-General of WHO was requested - *inter alia* - to "use appropriate mechanisms, in close collaboration with the global and regional Advisory Committees on Health Research to: (a) assess new and emerging areas of science and technology; (b) investigate evolving problems of critical significance to health; (c)

identify appropriate methodologies for trend assessment and forecasting, including epidemiology to improve health". Another important requirement was to develop further a clearly enunciated health research strategy for WHO.

To follow up on this resolution, the ACHR drew on the work of its own subgroups, namely, the Task Forces on Science and Technology, on Health Development Research, on Evolving Problems of Critical Significance to Health and the Subcommittees on Health and the Economy and on Research Capability Strengthening. It was felt that proper emphasis had to be given to infrastructural, economic, environmental and behavioural aspects. A document entitled "Research for Health - Principles, Perspectives and Strategies" was published in 1993, stressing WHO's dependence on new knowledge and the optimal application of science in developing its policies, strategies and plans.

In 1994, a joint "colloquium" between ACHR and CIOMS was held with the objective of drawing attention to and documenting certain of the most critical current and potential developments in science which are likely to have a major impact on medicine and public health over the next 20 years. Discussions ranged over the health and research implications of advances in biological sciences, physical sciences, technology, epidemiology and health systems research, behavioural sciences, social sciences, ecology and the environment, bioethics as well as future-oriented approaches. The Colloquium provided the forum to assess the present state of science relative to health, to review the trends in science and technology with respect to future health projections and to identify existing and potential constraints regarding their application to problem solving in human health and development. Proceedings of this "Colloquium" were published in 1995.

More recently, a WHO document entitled "Health for All in the 21st Century" was produced, outlining

overall WHO policies, and mentioning also the role of the Organization in “Fostering the use of, and innovation in, science and technology”. It realised that over the next decades, rapid progress should allow poorer countries to take maximal advantage of developments in technology and benefit from the experiences of other countries. A good example was Information and Communication Technology (ICT), which offered opportunities for the most remote researchers to access critical information and to participate fully to scientific progress.

Consequently, this “Research Policy Agenda” was developed by the ACHR in order to provide scientific backing to the policy formulation process and pursued three major thrusts.

The first one examines the global health situation in the light of trends which may seem “a priori” not to be directly related to health (e.g. population dynamics including migration and urban growth, industrialisation, changing value systems, etc.). Its orientation reflects the notion of “evolving problems of critical significance to health”.

The second component is a call to harness the extensive potentials of Science, Technology and Medicine which is available already, world-wide. The underlying argument is that the world needs to re-orient at least part of “frontier-type” research towards “global” problem-solving and the promotion of health development for the under-privileged communities.

In the following parts of the agenda, research imperatives and opportunities are discussed, in terms of substantive domains (domain vs. inter-domain types of research) as well as in respect of methodological needs (e.g. utilisation of knowledge, methods for inter-sectoral research, methods for behavioural research, health measurement and monitoring, modelling and simulation, priority setting methodologies, constraint logic programming and resource allocation, etc.).

A final section discusses implementation aspects.

Intelligent research networks (or “IRENEs”), that are making full use of advanced information and communications technology, are proposed to link up proactively all relevant partners, including foundations, governmental sponsors, research councils, and scientific unions and colleges, while making full use of modern communication technologies.

The chair wishes to acknowledge the valuable contribution of all those who have been associated with the ACHR system, who participated in the workshops held at Schloss Reisensburg (Germany) as well as others whose advice and critique were provided. Special thanks are due to the ACHR drafting Committee\* and to Dr A. Piel who was instrumental in finalising the report. Thanks are also due to the Merckle Foundation and to the personal support of Dr A. Merckle, without whose support the whole project could not have been accomplished. Finally, we are most indebted to Professor F.-J. Radermacher, director of the Research Institute for Applied Knowledge Processing (FAW) at the University of Ulm, for his continuous advice and support.

*Professor T.M. Fliedner (Chairman, ACHR)*

*Dr B. Mansourian (Secretary, ACHR)*

August 1998

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\* (Professor F.M. Fliedner, Professor W. Karczewski, Professor M. Manciaux, Professor B. McA. Sayers, with the support of K. Beyrer, G. Brauer, C. Greiner, U. Reischl, in Ulm)

# 1 Scope and Purpose

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Acting in its capacity as the primary expert advisory body to the World Health Organization on scientific research policies and practices relating to international health work, the Advisory Committee on Health Research (ACHR)<sup>1</sup> has undertaken the development of a “Research Policy Agenda for Science and Technology to support Global Health Development”. The Agenda presents an overall policy to guide research and a new strategic approach to carry it out, which is designed to complement and support the WHO policy and strategy for Health for All in the Twenty-first Century.

Despite indisputable progress, the health status of the world population is not what it could and should be at the end of the 20th century. Health, like wealth, is badly distributed and billions of people, especially poorer populations in the developing countries, do not benefit from many current advances in science and medicine. Moreover some plagues that once were thought mastered are reemerging, together with new diseases. There are many complex reasons for this, involving biological, social, economic and environmental determinants beyond the scope of any single scientific disciplines. As powerful as it is, modern medicine cannot solve by itself the many complex problems confronting the health of the mankind.

There are important interacting determinants of health which, in the absence of innovative global research and intervention, will almost certainly limit any substantial worldwide improvement in health status. The most worrying issues and trends that are negatively influencing global health include uncontrolled population growth and migration, anarchic urbanization and industrialization, environmental degradation, poverty and inequitable access to goods and services, social and economic upheaval, under- or overnutrition and unhealthy individual and collective behaviours. In too many parts of the world poverty is dramatically increasing, and the gap between needs and expectations on the one hand, and resources and the will to act on the

other, is widening. The exponential growth and disproportionate impact of some of these determinants represents a new dimension to the challenges facing those individuals, agencies and organizations responsible for improving the health status of the world’s many peoples and communities.

In spite of these very serious obstacles to global health improvement, the development of health status of the world’s population during the early years of the 21st century could be positively affected by many of the dramatic advances, not only in the medical and “health”-sciences, but also in the enormous range of other scientific disciplines that can contribute to health objectives. What is needed is a global policy and strategy of concerted action to ensure that the required research and development (R&D) initiatives are undertaken. However, there is a major problem: the global scientific community, i.e. those best equipped and mandated to mount a concerted scientific attack on health impairments, has been insufficiently involved or informed and has shown too little interest in launching and leading the kind of sustained R&D initiatives needed. The proposed Research Policy Agenda is an attempt to remedy this detrimental situation. Its purpose is to outline the range and complexity of research needed for health development, and provide a policy and a strategy to mobilize the scientific manpower and the scientific community at large in order to engage it to develop and share the knowledge and the know-how needed for improving health worldwide.

Starting from a vision for global health, the Research Policy Agenda reviews evolving problems of critical significance to health, and suggests ways of harnessing the power of science, technology and medicine to contribute to problem resolution. The Agenda highlights a number of “research imperatives” and “opportunities”, but does not attempt at this stage to provide an ordered list of research “priorities”. One reason for this approach is that “priorities” depend on **for whom** they are established. Each national and even local government has its own political priorities. Donors

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<sup>1</sup> The Advisory Committee on Health Research - An Overview. WHO/RPS/ACHR/97.1.

and other institutions have their own institutional priorities, reflecting their respective mandates, capacities and resources. What motivates the scientific community is the pursuit of intellectual opportunity and purpose, and it is therefore useful for them to know the needs and priorities of others. Research priorities cannot be dictated, but they can be arrived at through a process of understanding needs and opportunities. Therefore, the Research Policy Agenda presents a concept and proposes to set in motion a worldwide system for more effective research priority identification, planning and implementation. It is proposed that WHO facilitate the networking of the entire research community,

together with all relevant partners in all countries, to bring the power of scientific research, knowledge and technology to bear on global health development.

In such a process, ethical issues, taking into account the various value systems throughout cultures and countries, are of paramount importance. However, as the world is becoming more of a global village, there should be increasing opportunity for shared clusters of basic values to be identified and agreed upon. Among these, the ethics of research for health is, at least, a significant element and a major additional challenge!

## 2 A vision for global health - challenges for research

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- ◆ A view to possible futures
- ◆ “Globalization” or a world “system”
- ◆ The mission of WHO in research
- ◆ Meeting the global challenge by science and technology

### 2.1 A view to possible futures

As it enters the third millennium, the world finds itself facing great challenges, in spite of the fact that there have been unexpected but remarkable worldwide changes in politics and economics. Whereas the use of advanced technologies is providing people with new opportunities, there is an increase in starvation and misery in many countries. In addition, prosperity, human culture, and human rights are being seriously threatened by a lack of control over population growth, destruction of the environment, the overconsumption of non-renewable resources, and an accelerating process of demand-stimulating innovation. One option, of course, could be “laissez faire”, that is, to let things take their course, solving problems piecemeal, and hopefully not too late. The Research Policy Agenda takes a different view.

It is becoming clear that present attitudes and paths to development must change. Certain development trends have to be redirected, or even reversed, and then embedded in new sustainable processes. Humankind must identify solutions which allow the transformation of dangerous trends and which will involve the accommodation of conflicting goals. A new kind of „global rationality“ has to be developed and accepted. A fair distribution of resources, wealth, and social security should be the cornerstones for future politics. The world needs a “contract” between societies to accept globally the principles of equity and solidarity and to implement a sustainable way of living for the future. In such a contract WHO and the scientific community should assume a prominent role and should accept their specific responsibilities. The ACHR system has recognized these challenges and initiated the

preparation of this document on the contribution of science and technology with specific emphasis on global health development. „A Research policy agenda for science and technology to support global health development“ is intended to lead on to an ongoing research planning process and an implementation methodology.

The vision of the Research Policy Agenda is one of global cooperation between the scientific community, governments, non-governmental organizations and all partners in public health, in an innovative approach that will “make a difference” - a profound difference - in the health status of the world in the Twenty-first century (see **Figure 1**).

In essence the Agenda advocates the timely sensitivity to evolving problems of critical significance to global health, the mobilization of and support to scientific networks for solving them through systematic research, and the effective communication of research findings to decision makers. The premises underlying the Agenda include the recognition that:

1. In spite of diversity, there is a common fate, condition and ethic of all humanity that unifies action for global health development;
2. While most health impacts are “local”, many underlying causes and potential solutions are “global” and multifactorial in nature;
3. Global health challenges, problems and determinants call for a more systematic global approach in support of action at international, national and local levels;

4. The world's scientists and scientific institutions must work together and with all relevant partners, not only in conventional "biomedical research", but in all research that contributes to health;
5. "Intelligent" research networks need to be expanded or developed around major issues, taking advantage of appropriate communications technologies;
6. A continuous process for definition, planning, implementation and evaluation of global research imperatives and opportunities is required.

## 2.2 "Globalization" or a World "system"?

It is increasingly and commonly argued that new global forces have eroded national borders facilitating the transfer of goods, services, people, values and lifestyles from one country to another. Socio-cultural, political and even religious influences, as well as economic, ecological and behavioural factors are perceived as shaping the future world order. "Globalization of trade, technology and travel" are quoted as important new phenomena with direct relevance to world health. Yet, interdependence between sectors and countries has been under investigation for several decades, including, for example, the "Club of Rome" studies. Is it possible to model the system?

Computer simulation models have been developed in an attempt to predict the behaviour of the entire world system. They have been characterized by a high degree of aggregation, based on a few variables: capital investment, population, food production, non-renewable resources and pollution. Early models predicted that an equilibrium state sustainable far into the future was only possible if industrial output as well as population were limited through growth regulating policies and if technological policies were instituted assuring resource recycling, pollution control, increased lifetime of all forms of capital and restoration of eroded and infertile soil. In those models, the health sector was largely disregarded.

It must be recalled that a social system is characterized by organized complexity and extensive subsystem interdependencies within the system's boundaries. Systems analysis permits to identify inputs, outputs and systems parameters and classify them within a hierarchical framework. Goals can be defined and a hierarchy of values established. In principle, resources can be assessed and allocated and priorities established within the framework of the overall system. Based on that, a rational search for solutions can be initiated and objectives and program activities can be properly articulated.

One of the major problems is the quantification of a system's variables. Conventionally, many social indicators are expressed in monetary terms, thus associating happiness with material welfare. National data collection and analysis based on averages are not geared towards identifying local pockets of poverty or of poor health conditions, despite the impact such pockets may have on overall performance. The use of the GNP of the poorest 40% of the population (GNP40) as a measure of income distribution has been proposed and the ratio of GNP40/GNP for typical developing countries has been found to be in the range of 0.17 to 0.41. Perhaps other measurements are needed to more fully capture the complexity of disparities, sub-system relationships and concepts of human welfare.

A pioneering effort<sup>2</sup> performed in the late seventies investigated the relationships between seven socioeconomic subsystems in a cross-national and cross-temporal study of 29 developed and 25 developing countries. The sectors considered as subsystems included demography, health, medical resources, nutrition, education, housing, communication and economy. The performance of these subsectors showed that certain changes could be closely correlated until a particular level of development was reached, then would vary at different rates. The ranking of all the countries along a socioeconomic and a health dimension showed that economy (a social dimension consisting of housing, nutrition and medical resources), health and

education contribute most to the rank order of developing countries, while a social dimension consisting of communication, housing and education assumed that role for developed countries. Although many countries in both groups showed relatively balanced development with respect to the socioeconomic and the health dimensions, two special groups could be identified as either “health efficient” or “health inefficient”.

Such analyses clearly represent the type of conceptualization which could contribute to a better understanding of global systems dynamics in world health.

## 2.3 The mission of WHO in research

### 2.3.1 Mandate

WHO has a clear constitutional mandate to “promote and conduct research in the field of health” (Constitution of the World Health Organization, Article 2n).

WHO has recently reaffirmed that it “will continue to promote and support health research and technological development in accordance with its policies and in response to the health problems in countries. It will identify important bioethical issues in certain aspects of health research and in their clinical applications, and will stimulate the exchange of opinion and the sharing of information in that regard. It will stimulate and support the strengthening of health research capacity in countries, with emphasis on affordability and

sustainability. By monitoring and analysing advances in medical, biological and behavioural sciences and health technology it will seek to identify existing technology that could be used directly or be further developed to solve significant problems in health care; to assess new and emerging science and technology for future application in solving health problems; and to catalyse research to meet known and emerging needs.” Also: “It will strengthen the collection, assessment and dissemination of information on cost-effective new methods for health development. It will explore new ways of intensifying cooperation with the scientific community and promoting more active involvement and collaboration.” (WHO Ninth General Programme of Work, para. 64, 65).

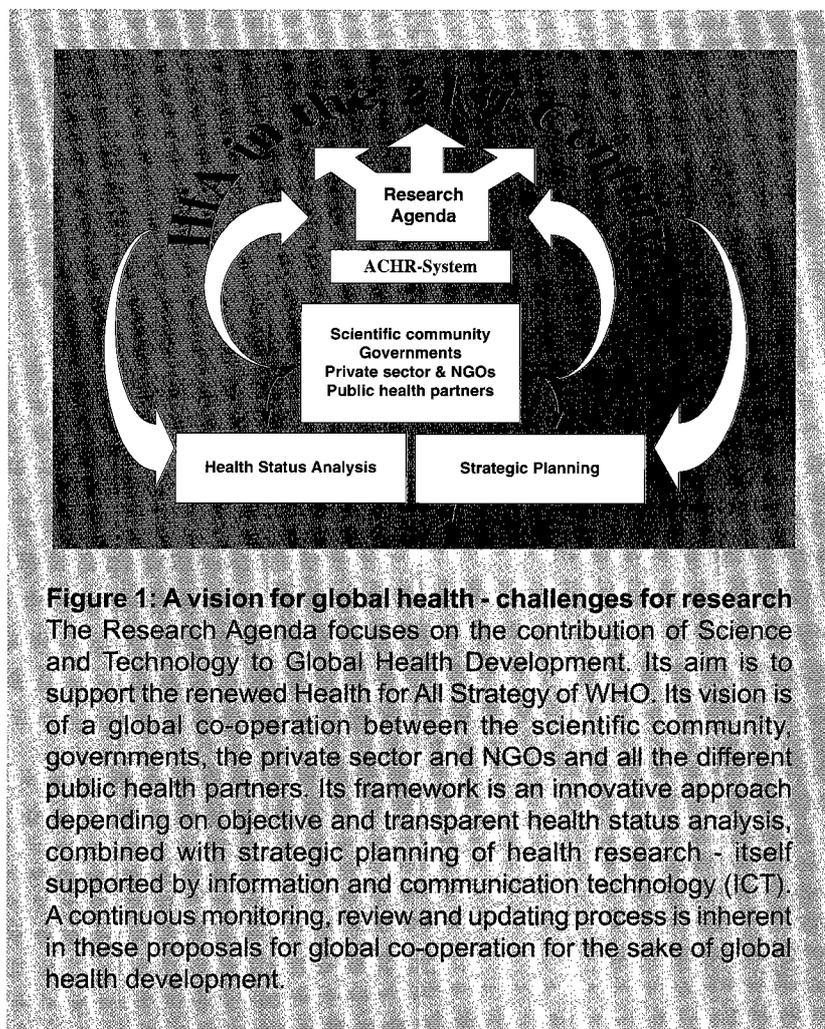
<sup>2</sup> Attinger, E.O., and Ahuja, D.R., „Health and socioeconomic -change”. IEEE Trans.Systems, Man and Cybernetics,10, 781-795,1980

### 2.3.2 Health Research Strategy

Prior to adopting the 9th GPW, the World Health Assembly, in 1990, called for a clearly enunciated health research strategy in order to translate the research goals, priorities and programmes into coherent and coordinated action in support of health for all (resolution WHA43.19). To fulfil this, the Advisory Committee on Health Research (ACHR), drawing on the work of its own task forces and subcommittees, considered that new dimensions were needed to give proper emphasis to the infrastructural, economic, environmental and socio-behavioural aspects of the health research strategy given in 1986. That previous health research strategy, known as the McKeown report, had interpreted the goal of “health for all by the year 2000” as aiming to achieve a substantial improvement in health in all countries, particularly those where the need is greatest. It stressed that “it is not unrealistic to define more precisely a level of health below which it is hoped that no country will fall: infant mortality below 50 (per 1000 live births) and life expectation at birth of 60 years.” These levels were reached in the middle of this century by the developed countries and more recently in some developing countries.

The determinants of the global health picture were also described and the consequential approaches to research planning were discussed, based on the following key observations:

- The human genetic constitution was much the same today as it was a hundred thousand years ago, before the advent of any form of pastoral or agricultural activity. That is to say, we now face vastly changed conditions of life with the same genetic equipment of our ancestors who were hunter-gatherers.



- The modern transformation of health in the developed countries and the associated increase of populations, which began more than a century before effective medical intervention was possible, was to be attributed largely to improvements in living conditions.
- Research had shown us the nature of infectious disease and the possibility of its prevention by environmental measures and immunization.
- It had been recognized in the last few decades that most noncommunicable diseases could be prevented by changes in living conditions and behaviour; the most striking evidence was the recent decline of coronary deaths.

In 1986 it was considered that countries with very limited resources should give higher priority to research and services in nutrition, immunization and sanitation.

In order to further elaborate the formulation of a WHO health research strategy, ACHR drew on the

### 2.3.3 “Health for All in the 21st Century”

A recent document entitled “Health for All in the 21st Century”<sup>3</sup> discussed the role of WHO in Fostering the use of, and innovation in, science and technology”. It stated that advances in science and technology have yielded substantial dividends to health in the past.

Scientific and technological progress was likely to yield even greater benefits for all in the twenty-first century. Rapid progress in several fields over the next decades should allow poorer countries to take maximal advantage of developments in technology and benefit from the experiences of other countries. Information and Communication Technology (ICT), for instance, offered opportunities for the most remote researchers to

work of its own subgroups, namely, the Task Forces on Science and Technology, on Health Development Research, on Evolving Problems of Critical Significance to Health, and the Subcommittees on Health and the Economy and on Research Capability Strengthening. The ACHR considered that although the Health Research Strategy adopted in 1988 remained a valid cornerstone of WHO’s research strategy, new dimensions should be added to give proper emphasis to infrastructural, economic, environmental and behavioural aspects. The revised strategy focused on: the relevance of health and the economy, global problems and global solutions, health research and human development, science and technology policies, the emergence of new ethical issues and research capability strengthening in developing countries. It further emphasized: a world in transition, the changing scene of science and technology, and the importance of identifying research needs on the basis of health needs. Research capability strengthening at country level was badly needed, and international cooperation in the field of constrained resources, that made it necessary to carefully define health research priorities.

access critical information and to participate fully to scientific progress.

Global research efforts should be directed towards areas where substantial gains are needed for health. These are complemented by country-specific research priorities and action, through which countries will work towards improved national and global health. It was concluded that global areas of concentration should include research that:

- identifies social, environmental and specific sectoral policies and actions that advance health;
- informs health policy and improves health equity;

<sup>3</sup>Health for All in the 21st Century. PPE/PAC/97.5.

- evaluates the effectiveness of interventions to reduce inequities in health;
- maximizes health systems efficiency and leads to sustainable health systems;
- accelerates the reduction of childhood disease, malnutrition, and maternal and perinatal mortality;
- addresses changing microbial threats and develops strategies for their prevention and control;
- identifies effective preventive, promotive and curative approaches to noncommunicable diseases and health consequences of ageing; and
- leads to control of violence and injuries.

Closer partnerships between science and technology, between users and innovators, and between the private and public sectors will increase

## 2.4 Meeting the global challenge by science and technology

A number of background studies have provided strategic, intellectual, methodological and technical contributions to shape up the Agenda. Some of these will be printed in a separate document to be made available in 1999.

It must be recalled that the global resources for science and technology are very substantial. The market economies (about 75% of the world) are spending approximately 2% of their GNP for research and development, i.e. of the order of half a trillion USD (including the private sector, 1997). The number of scientists and engineers worldwide exceeds 4 million (UNESCO, 1996) with a ratio

the chances that innovations in science will contribute to improved health worldwide through the development of technology and the implementation of research. The scope of technologies for health extends from those that provide a direct benefit to health such as genetic modification, biologicals, pharmaceuticals and medical devices to those that are supportive of health systems functions, such as telecommunications, information technologies, devices for environmental protection, and food technologies.

It was concluded that in assessing and promoting new technologies for health, the following should be considered: their ability to contribute to life and health; to promote equity; to respect privacy and individual autonomy and the extent to which they focus the determinants of health. At the same time, an effort must be made to adopt a long time frame and a wide view, as the benefits and applications of technology are not always immediately understood, realized, or affordable.

between North and South ranging between 25:1 (average) and 7:1 (China). These resources are obviously maldistributed and not matched to the problems which face the world.

The challenge is to involve all of the world's human resources, North, South, East and West, to investigate and solve global health problems by working together and exploiting modern communication technology. It is argued that research imperatives and opportunities need to be continuously identified and further developed and refined.

### 2.4.1 Global health problems call for a global approach

The **first** component of the Agenda is an appreciation of the need for doing comprehensive research on complex problems - not discipline-specific problems. The global health situation reveals the fact that the world is not confronted merely by health problems as such, but rather by an intricate system of interacting factors and trends, many of which do not seem (a priori) to be directly related to health. When such trends as are seen in population dynamics (growth, migration,

urbanization industrialization, environmental degradation, (human) behaviour, and changing value systems) are studied, not in isolation but in interwoven human systems, then it becomes feasible to devise solutions within the boundaries of realistic constraints. Best seen as constantly **evolving problems of critical significance to global health** (see Chapter 3), these issues are at the core of health development.

### 2.4.2 The world's scientists must work together

The **second** component is based on the recognition that while the world boasts a large and increasingly skilled cadre of scientists and technological experts, the skills and experiences of these individuals have, up to this point, not been sufficiently recruited to solve global health problems. Scientists, particularly those in the world's many universities, rarely conduct joint research into what are often less than "cutting-

edge" topics, e.g. better procedures for food safety, water quality, infant care, immunization, etc. This aspect of the Agenda consists in **harnessing the power of science, technology and medicine**, and calls on the world's scientific community to combine their, hitherto often fragmented, efforts in the direction of research for "global" problem solving.

### 2.4.3 Intelligent research networks will be required

The **third** part of the agenda is the networking of global scientific brain-power in small, *intelligent research networks* (or "**IRENES**"). It is proposed to use Information and Communication Technology (ICT) for the establishment and coordination of a worldwide "network of scientific networks". The Global ACHR has already developed the prototype for the central node of this "meta network": a *planning network for health research* (or **Planet**

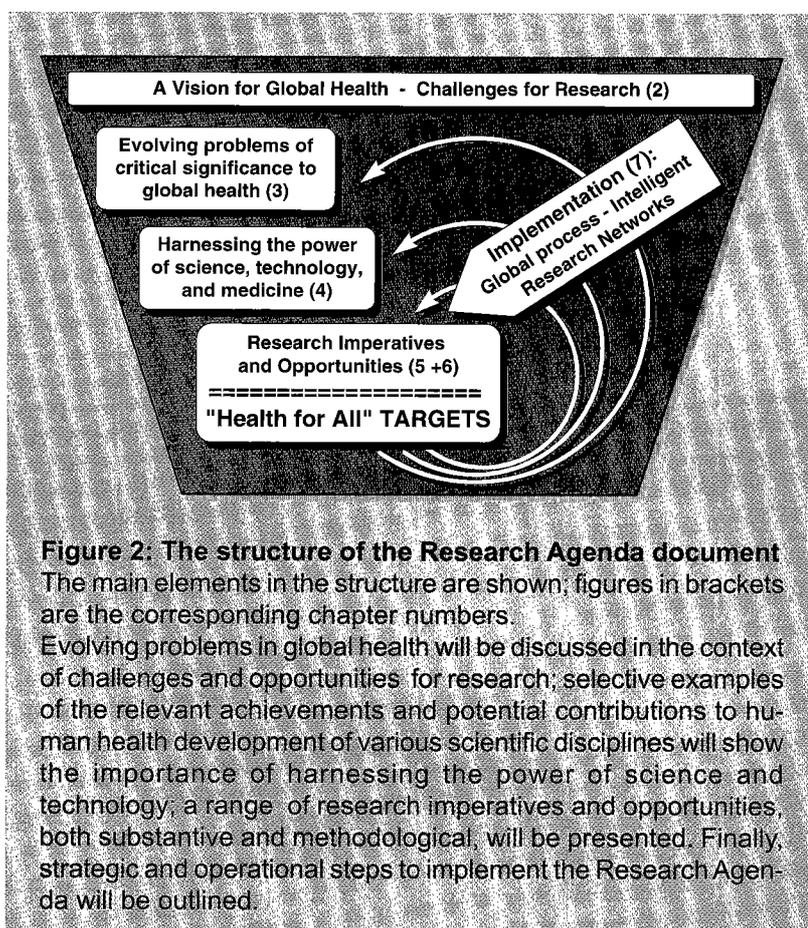
**HERES**). This key network will help call the "IRENES" into life by recruiting scientists and organizing the other partners necessary for the success of the research initiatives - foundations, governmental sponsors, research councils, and scientific unions and colleges will all have to play a role in the establishment and fostering the work of the "IRENES". (See section 7.1.2).

## 2.4.4 Defining research imperatives and planning global research

Having the resources and the machinery does not amount, however, to knowing what work there is to be done: of all the work to be tackled, which should be done, and with which urgency? There is a virtually unlimited amount of potential research which needs to be undertaken. However, there can be no prospect of substantial progress if there is not at the same time some degree of order in the research process. It is the process (and product) of establishing, promulgating, and monitoring of this order which represents the **fourth** and last component of the Agenda. To address the evolving health problems research imperatives and opportunities outlined in Chapters 3, 5 and 6, a **continuing process for the definition and planning of global research imperatives** (Chapter 7) is required. This research planning process will, in turn, be based on a combination of IRENES, Planet HERES and appropriate methodologies, all combining their unique features to create new and useful information for WHO, national and international agencies as well as other “stakeholders” in the global research enterprise. (The structure of the Research Policy Agenda document is schematically presented in **Figure 2**).

There are “tasks” to be performed by various partners with resulting “products” which translate into practical development and interven-

tions as well as into capacity building. Many of the boundary factors of such a system are determined by developments in the market economy and in overall governance and by the conditions of support in the donor community and the extent of resources in the scientific community. The primary determinant of success will be the imagination, energy and will of the people and institutions engaged in the common enterprise.

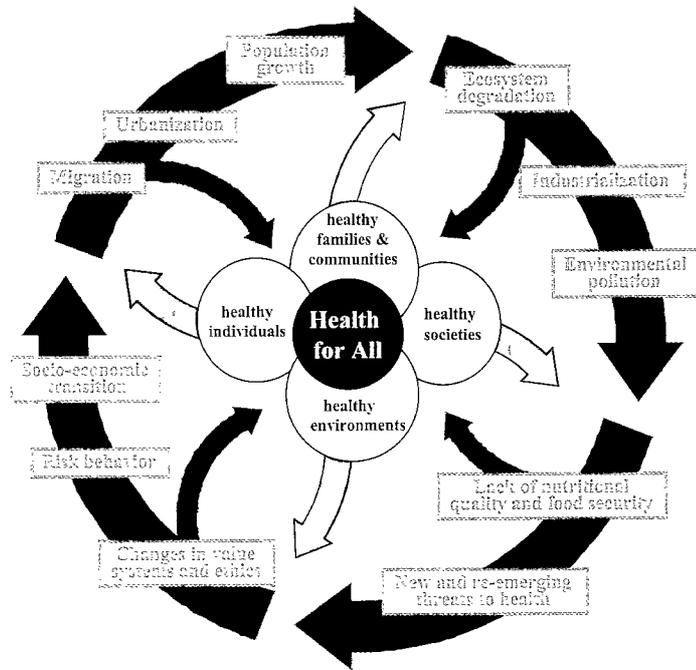


### 3 Evolving problems of critical significance to global health

- ◆ Evolving problems of critical significance to global health
- ◆ Definition of significant, global imperatives
- ◆ Population dynamics
- ◆ Industrialization and urbanization
- ◆ Environmental threats
- ◆ Food, nutrition and water supply
- ◆ New and re-emerging threats to health
- ◆ Behavioural and social problems
- ◆ Challenges ahead
- ◆ Value systems, ethical issues and research for health

Global development problems result from complex interactions between natural and man-made systems, with biological, environmental and socio-behavioral factors playing a major role. Several components and trends are of special relevance and pose challenges to science and technology: population dynamics, mobility and migration, urbanization, industrialization, employment, energy, environment, food supply and nutrition, social behaviour, new and evolving diseases and - more generally - the interaction between development and health. All of these impinge on the health of individuals, families, communities, societies and the environment - in short, health for all (See **Figure 3**).

The past decade has seen rapid and often unpredicted changes in the global political situation, world socioeconomic conditions and the environment, as well as demographic and epidemiological transitions. For example, rapid aging of the population and changes in lifestyles and the environment account for the increasing



**Figure 3: Evolving problems of critical significance to global health**

Critically significant evolving problems are complex. Many causal and contributing factors influence human health (outer ring); however, many of these factors are not yet fully understood, or perhaps even identified.

The concept of Health for All can be separately focused onto different target areas such as: healthy individuals, healthy families, healthy societies, and healthy environments. Each of these is interlinked with the others. Understanding the various interactions in their impact on human health will be a vital step in finding sustainable solutions to evolving problems.

prevalence of cancer, cardiovascular diseases, diabetes, accidents, suicide, dementia and other chronic conditions. In developing countries the double burden of communicable disease and „diseases of affluence“ is being aggravated by the spread of the AIDS pandemic and the resurgence of such ancient scourges as malaria, tuberculosis and cholera. Many of these health problems transcend national boundaries, calling for global solutions which require coordinated and intensified research.

Demographic growth remains a priority issue since, according to the United Nations medium-variant projections, world population is expected to reach 6000 million by the end of the century and to exceed 7000 million in 2100. Attempts to check the rate of population growth are vital.

The finite nature of natural resources, indiscriminate storage of industrial wastes leading to pollution, the widespread use of aerosols causing ozone depletion, and carbon dioxide emissions producing the green-house effect: all these are well-publicized examples of worldwide problems. The issue of energy use is linked with the process of industrialization and the application of technology. As a consequence, thousands of environmental contaminants are being encountered, particularly in occupational settings. Methodology needs to be developed further in order to assess the impact of low doses of contaminants typically found in the ecosystem.

Turning to food supply and nutrition, several dimensions need to be investigated:

- Availability of and accessibility to food, production and distribution, quality control, marketing and international trade, as well as the contrasted situation in food consumption and in diseases associated with inadequate nutrition as between the North and South.
- Partly common with these problems, those of water supply and quality are also of

increasing concern.

The need to understand the origins of health-damaging behaviour and, more important, to identify the approaches and design the means by which healthy lifestyles may be encouraged, means that behavioral research is needed. The scope of research must comprise the behaviour of individuals, families, communities and organizations, including that of individuals within such groups.

Finally, and taking into account the cultural specificities and the various value systems throughout the world, policy makers and the scientific community are facing a variety of technical and ethical issues which require further investigation. All these problems are of critical significance to global health, but it is important to provide clear definitions of the terms used here.

Accordingly, the key-concepts: significance (with respect to health-related problems), globality (with respect to significant health-related problems) and global research imperatives need definition.

**A health problem will be considered significant if it:**

- contributes substantially to the burden of illness in a population, in terms of prevalence and/or severity;
- is perceived (due to technological advances, better communication, etc.) to be amenable to improvement, thus increasing political pressure for corrective action;
- represents a major and identifiable cost to the taxpayers and/or the health care system; or
- has the potential of becoming a significant risk to community health status and general welfare.

**A significant health problem will be considered to be global in scope if it:**

- affects people in many regions;
- affects people in only one or a few regions, but has the potential and probability of affecting people in many regions;
- can not be solved by one region alone;
- is limited to a certain region, although research results are generalizable to many regions;
- calls for R&D which is likely to have a high paradigmatic value (e.g., in terms of research methods).

**Global research imperatives are characterized by:**

- their global and regional significance;
- the involvement of more than one domain of health;
- the cross- and intersectoral nature of the addressed research issues;
- the needs for trans-national cooperation;
- the outcome would have universal relevance and a return for all partners.

### 3.1 Population dynamics

Population dynamics is concerned with population growth, structural change and population movements. These have tremendous implications for individual as well as global health and well-being. How population issues are addressed can tip the balance between poverty and opportunity.

Considering the dynamics of human development during the past and the next 20 or so years, it is clear that mankind has entered a period of unprecedented population growth. Indeed, the world population is in a dynamic state of largely uncontrolled increase. In 1996, the number of people living on this planet was about  $5.8 \times 10^9$ . In twenty years from now, as indicated by realistic UN predictions, the number of people will be about  $8.5 \times 10^9$ ; in 100 years, there may be as many as  $12 \times 10^9$  people. Due to the significant differences in population growth rates between North and South, 80% of the people in the year 2020 will live in the so-called “developing” part of the world.

Another area of concern is the changing patterns in the age structure of the world population. Due to

an improvement in socioeconomic standards and in availability of health care services, the overall life expectancy increased steadily over the past century and will continue to do so. At present, in industrialized countries, 17 percent of the population is older than 60 years and this percentage will rise to about 25 percent in 2025. This poses a tremendous burden for future generations and for socioeconomic development, not forgetting the influence of aging on quality of life with all its impact on political, administrative and institutional decision making.

The developed world, with less than one quarter of the total population, accounts for about 85% of the gross world production and for the majority of mineral and fossil-fuel consumption. This inequity of distribution generates, in many developing countries, the more than legitimate wish to participate in prosperity, well-being and quality of life seen in the North. As a consequence, it can be predicted that the present migration trend of people will continue: from economically poor to richer countries, from rural to urban centers, and from war-shattered to more peaceful regions.

In the mid-1990s, about 125 million people lived outside their country of birth or citizenship. They accounted for about two percent of the world's population and their number is increasing by two to four million annually. This push of poverty and pull of opportunities together with all the other causes for migration like political persecution, religious suppression, warfare, or environmental deterioration, create enormous changes and challenges to socio-cultural, political, infrastructural, administrative and health care systems.

Since the end of the Second World War, more than 400 armed conflicts - mainly civil wars - have spoiled or ruined many third world countries. They have killed almost 40 million people, mostly women and children, and expelled, either within their own boundaries or abroad, a total number of 27 million refugees and displaced persons, of which about fifty percent are hosted in Africa and Western Asia.

### 3.2 Industrialization and urbanization

The dimensions of the "population dynamics" problem outlined above imply the need for a further growth of industrialization. This requires energy and has already become an increasing burden to the ecosystem. Traditional energy resources will decrease; therefore, the development of new ecologically sustainable sources will constitute a big challenge; it is estimated that in 2020, energy consumption will have doubled world wide. But industrial developments generate problems of waste management - and no longer only at individual country level. It becomes a global problem when richer countries try increasingly to export hazardous waste to poorer countries. One indicator of industrialization is CO<sub>2</sub> emission which is thought to be associated with ozone depletion. The CO<sub>2</sub> concentration increased from 280 ppmv (parts per million by volume) in pre-industrial times to 358 ppmv in 1994. It is expected that CO<sub>2</sub> concentration will further increase to about 410 ppmv by the year 2020. Different scenarios predict CO<sub>2</sub> concentrations

of 600 ppmv to up to 900 ppmv by the year 2100, depending on different economic and population growth rates.

It seems clear that both internal and transboundary migrations will continue, causing manifold problems. Whenever too many or too diverse peoples - culturally and/or economically diverse - are forced to share a limited amount of space, resources and prosperity, it is very likely that (perhaps out of a false perception of a need for self-preservation), people are more ready to resort to violence of different kinds and dimensions.

The relationships between population growth, aging, migration, economic development, natural environment, resource use and violence are complex and not yet fully understood. Impact on the equilibrium of the ecosystem is multifocal and self-stabilising mechanisms in the ecosystem are at risk of failure. This constitutes a wide field for research, as discussed further in Chapters 4 and 5.

The excessive exploitation of non-renewable resources by industrial processes is a major source of concern. Addressed under the rubric of "sustainable development" these issues are receiving more and more international attention. Their impact on global development will in future become extremely important, even more so because most developing countries are now entering into the industrial period. Some of them follow western standards and, due to the low cost of their manpower, rival the West. Some others, using inadequate technology, consume a lot of raw material and energy and are polluting the soil, the water and the air.

For its part, the developed part of the world has already reached the post-industrial era, with an ever

increasing productivity: which means more products - the "consumption society" - with less manpower. The rate of unemployment is rising, affecting especially the young people. It is quite obvious that a new relationship between man and work is to be found: the traditional way of working is over. For quite different reasons, unemployment constitutes also a plague for the developing countries, with a rate reaching fifty percent in many places. The lack of paid work is a major obstacle to the socialization of young people and a threat to the stability of society. Occupational health services have to expand and adapt their activity to cope with these unprecedented challenges.

Due to shrinking economic opportunities in rural areas and the prospect of enhanced opportunities and services in urban settings, there is an increasing process of urbanization all over the world. This process is even accelerating. On present trends, half of the world's population will be urbanized by the year 2005, and two thirds by the year 2025. In 2025, some 4 billion people in developing countries will be classified as urban, which is the equivalent of the world's population in 1975.

The UN-Habitat II Conference in Istanbul in 1996 pointed out that there will be a tremendous increase in the number of mega-cities with more than eight million inhabitants. Their number will grow from 22 at the present time to 33 in about 20 years from now, the majority being in the developing world.

### 3.3 Environmental threats

As an integral part of local, continental and global "ecosystems", human society and the health of human beings should and must be at the centre of our attention. Pollution takes a toll on human health, and there is increasing evidence of interaction between large-scale environmental, developmental and demographic changes, and ill health. It is necessary to explore the synergy among these elements and to assess policy options to reduce hu-

The advantages in employment, education and access to medical care, which were initially attached to this process of urbanization, at least in the developed world, are now counterbalanced by the uncontrolled influx of poor people migrating from rural areas. People living in decayed inner cities, in slums or in periurban fringes represent between 30 and 60 % of the urban population in low income countries. They do not benefit from urban advantages. On the contrary their living conditions (overcrowding, promiscuity) and the environmental threats (air, water and soil pollution) are responsible for a high morbidity and mortality, especially for babies and young children (Health and Environment in Sustainable Development, WHO, Geneva, 1997). At the same time, the environmental impact of these growing mega-cities is tremendous. People in urban areas tend to consume more industrial goods and energy-intensive services and generate air pollution, water pollution, and huge amounts of solid waste. The effects on human health are obvious. These problems are not only of socioeconomic nature, but also pose managerial problems for the infrastructure, for the urban environment and, in particular, for health and health care services. This urbanization trend will also affect the socio-cultural heritage, traditional family structures and will also lead to a shortage of farming resources and a decay of local food production capacity. Violence, ghettos, pauperization are other self-explanatory keywords in this context.

man risks. Industrial process experts, economic modelers, and health professionals analysing the quantity and nature of global chemical releases into the environment conclude that both the amounts and risks are greater than generally believed - even in the United States and other developed countries. The presence of toxins will soar by 2050 if today's industrial practices grow at expected rates. This trend has significant implications for development

and trade and for the nature of global interactions on environmental management.

One piece of the toxics puzzle is the effect of pesticides on mammalian immune systems. Pesticides suppress the immune system of test animals in laboratory experiments. Evidence from human epidemiological studies is less thorough, but consistent with laboratory and wildlife studies. If it turns out that exposure to these chemicals makes people - especially children - less able to fight off disease, the implications are enormous, especially in the developing world, where the lives of 200 million children under age five are already jeopardized by malnutrition.

Concern about chemicals in the environment is just one element of the health/environment challenge. The impact of climate change on human health, threats from emerging viruses unleashed when habitats are disrupted, public health issues in developing countries stemming from air and water pollution, occupational hazards, and the close links between environmental degradation, poverty, and health all demand attention. The UN Intergovernmental Panel on Climate Change forecasted that due to presumed global warming the average temperature will have risen in 2030 by about 2° C above the pre-industrial levels (1.1° C above 1995 levels) and by 2090 by 4° C (3.3° C above 1995 levels). There is a strong relation between presumed global warming and the build-up of greenhouse gases resulting from human activity.

### **3.4 Food, nutrition and water supply**

The food supply has increased throughout the world, except in sub-Saharan Africa, and the food availability per capita reached, in 1992, 2720 calories per day, compared to 2300 twenty years ago. However, it is estimated that over 800 million of people do not get their basic daily food intake and that 200 million under-five children are still

It is now recognized that climate change, by altering local weather patterns and by disturbing life-supporting natural systems and processes, would affect the health of human populations to an extent not yet precisely predictable. The causal relationships involved are complex and multifactorial. With the help of scenario-based risk assessment concepts, the impact on human health and changes in mortality patterns will be simulated. Examples include: the increase of death due to an increase in frequency and severity of heat waves; the increase of malaria incidence in northern regions due to a change in breeding conditions for the mosquito population; the impact of climate changes on farming and food production; or the change of migration patterns with population displacement and conflicts following a sea level rise.

On the other hand, increasing numbers of man-made chemical, or radioactive incidents or accidents and other human interventions in the environment reveal to certain extent an alarming readiness - in the interest of private profit or the supposed growth of the national economy - to take risks, not just with the safety of particular communities but with the biosphere itself. An international code of environmental ethics is urgently and badly needed. All these problems are studied in detail in the above mentioned report prepared by WHO for the June 1997 New York conference, 5 years after the Earth Summit (Health and Environment in Sustainable Development).

suffering protein/calorie-malnutrition. Almost 3 billion people are deficient in one or another micronutrient or vitamin, the most prevailing deficiency being anaemia by iron deficiency that affects more than fifty percent of pregnant women in developing countries. According to FAO/WHO, also 20 % of women and 17 % of pregnant women

are anaemic in the developed world, and twice as many are iron deficient, making this nutritional disorder a huge public health problem worldwide.

To contrary effect, millions of people in the industrialized world and many of the well-to-do in developing countries are overweight through over- and malnutrition, with an increased risk of developing chronic diseases like diabetes, hypertension, cerebro-vascular diseases. This contrasted situation should be kept in mind when one speaks of food production and food safety. Moreover, two worrying problems exist in relation to world population: will food production keep pace with the increasing needs of a growing number of human beings; and how can good quality of food as well as balanced and safe nutrition be ensured?

As far as food availability is concerned, discussions about the future of global agriculture take place in an unusual context: production is generally growing and is likely to continue to grow, but globally the rate of growth is slowing, dropping from 3 percent annually in the 1960s to 2.3 percent per year in the 1970s and to 2 percent during the 1980 to 92 period. The trend is similar for world cereals production. At the same time, about 90 million people are being added to the world's population every year, putting more pressure on the world's food production system.

In the face of these declining growth rates, many experts are concerned about the capacity of the world agricultural system to continue to increase production over the coming decades to feed an ever-larger world population. Other experts worry not so much about the growth potential of global production as they do about the poorest countries of Africa and Asia and the continuing prevalence of chronic undernutrition in those regions, where population growth is still relatively high and poverty persistent. A further concern is whether there are ways to increase production while at the same time

reducing environmental and resource damage. Without entering further in this debate, it can be argued that potential remedies have to be found; perhaps in innovative technologies in food production and processing, in reduction of spoiling, losses and waste, and in better sharing of available food.

As to food control and food safety, in order to diminish both acute and chronic foodborne diseases and poisoning, new techniques and models of quality assurance are being used. However, many problems exist in the various steps of the food chain from production to consumption; food hygiene is to be developed and taught in domestic and collective settings in order to achieve better use of foodstuff.

The same kind of problems are at stake concerning water supply and quality. Water is unequally distributed throughout the world and the most populated countries are in the South where climatic conditions (drought, desertification) diminish the availability of water and its quality. In 1994, 1,100 million people living mostly in rural areas had no access to safe water. In some areas, wetlands also are being converted to croplands. As demand for irrigation water consumption increases, the over-extraction of ground water - already a serious problem in the Near East and in parts of South Asia - will likely worsen. Almost everywhere the extensive use of pesticides and fertilisers is responsible for the contamination of surface water by poisoning due to substances like nitrates, making it not drinkable. In many countries of the world, waterborne diseases are common, either endemic or epidemic, and especially affecting infants and young children. In 1987, WHO estimated at about 4 billion the total number of diarrhoeal episodes with 3 million deaths. These many threats to health and life are of great concern to WHO and will require extensive research and investments in the near future.

### 3.5 New and re-emerging threats to health

Emerging infectious diseases were chosen as the theme for World Health Day 1997 to send a clear and urgent message: infectious diseases are still with us and their detection and prevention must be intensified. Until quite recently, there was a widespread feeling that the struggle against infectious diseases was almost won. The means of controlling most of them seemed either available or discoverable without undue difficulty. Spectacular progress has indeed been made: smallpox has been eradicated and six other diseases will be eradicated or eliminated soon. But tragically, with optimism came a false sense of security, which has helped many diseases to spread with alarming rapidity. Major diseases such as malaria and tuberculosis are making a deadly comeback in many parts of the world. At the same time, diseases such as plague, diphtheria, dengue, meningococcal meningitis, yellow fever and cholera have reappeared as public health threats in many countries, after many years of decline.

In addition, previously unknown infectious diseases are emerging at an alarming rate. In the last 20 years, more than 30 new and highly infectious diseases have been identified. They include the virulent Ebola-type haemorrhagic fever, HIV/AIDS and hepatitis C. For many of these diseases there is no treatment, cure or vaccine. Antibiotic resistance is another important threat to human health which has emerged during the last 20 years. Drugs which once could be relied on for protection against many infectious diseases have been indiscriminately used and are becoming less and less effective as resistance to them spreads. In addition, fewer new antibiotics are being produced, owing partly to the high costs of development and licensing. As the treatment of communicable diseases becomes less effective, more people need hospitalization with an additional risk of nosocomial infections by even more resistant microbial stems, illnesses last longer, treatment costs more and absence from school and work increases.

There are many reasons for the appearance of new diseases and the resurgence of communicable diseases once thought to be well under control. These include the rapid increase in international air travel and the growth of mega-cities with high population densities and inadequate water distribution and sanitation systems. The risk of foodborne diseases has been heightened by the globalization of trade and changes in the production, handling and processing of food. Environmental factors can lead to the exposure of humans to previously unknown diseases. For example, man is destroying forests and moving into previously remote animal and insect habitats which carry high risks of exposure to disease. Last but not least, the permanent adaptation of bacteria and viruses to their hosts makes the fight against them an unfinished burden.

Meanwhile, in rich and poor countries alike, resources for public health are being reduced as shrinking funds are spent on other priorities. As a result, the appearance of new diseases, the re-emergence of known diseases, or the development of antibiotic resistance may go unnoticed until it is too late. A recent striking example is the human immunodeficiency virus which was recognized only after it had already infected large numbers of people in many countries. If diseases of epidemic potential are detected early enough, epidemics and pandemics can be prevented in some cases, in others minimized.

Paradoxically, one of the main reasons for a false sense of security has been the success of the worldwide effort led by WHO and involving countries, UN agencies, international organizations, NGOs and others in controlling some of the most terrible diseases facing humanity. Smallpox has been eradicated and other diseases such as poliomyelitis, leprosy and guinea-worm disease (dracunculiasis) are targeted for eliminating or eradication in the near future.

Both the public and the private sectors must be encouraged to search for and develop better techniques for surveillance, alerting and control, and for new antibiotics to replace those which are no longer effective. “The biological cauldron that churns out new flu variants is working as ever; and we are especially vulnerable with a unique state of human culture that combines unprecedented population density, hygienic stratification and unmitigated travel. The public does not understand how fragmented our existing programs are, how little is left after the appropriate allocations for AIDS and tuberculosis, and how naked we are in regard

to vaccines for newly evolved agents. Nor is it aware of the rapid failing of our repertoire of antibacterial antibiotics, and the virtual desert of chemotherapeutics for viral infections. Here, then, is another vast area of challenge for the interdisciplinary approaches that are the hallmark of the new public health: to put the most sophisticated science at the service of the most people.” (Joshua Lederberg: “Medicine, Science, Public Health must merge for the greater good”. Essay for Medicine and Public Health. September 1996.)

### 3.6 Behavioural and social problems

The lifestyles of affluent societies - a too rich and unbalanced diet, a sedentary way of living, not to mention alcohol abuse and tobacco use - is known to be conducive to an increased risk of “diseases of affluence” such as diabetes, coronary heart disease and stroke. However, behaviour change is difficult to achieve, both at individual and community level; the reason why it is so is by itself a huge field for behavioural and social research. It is a matter of great concern that the global spread of unhealthy lifestyles will lead to an increase in the “double burden” of developing countries.

According to the Human Development Report, there are in today’s world at least five types of growth - very often combined - that give people less and not more: “rootless, ruthless, jobless, voiceless, futureless growth“. To this list could be added “restless” growth, embracing the problem of violent behaviour.

“Rootless” growth: there are about 10,000 distinct cultures in the world, but many risk being marginalised or eliminated. This cultural diversity - which represents together a wealth and a challenge - and the rights and survival of ethnic minorities should be protected by all means. This also applies

to the migrant populations whose cultural background and values are frequently considered as “subcultures” by their host country.

“Ruthless” growth: the process of globalization and the forces of “free market economy”, while offering many advantages, may in some situations create increasing polarization between the “haves” and the “have-nots”, between countries and within countries.

“Jobless growth”: unemployment affects particularly developing countries but the picture is far from good in many industrialized countries either. The so-called “economic crisis” is in fact a social equity crisis, a transitional period between a traditional way of living and working and new models being invented. New types of relationship between human beings and work will have to be developed taking into consideration the changing patterns of employment. Such issues as the reduction of working time, job mobility, educational investments in order to prepare young people to these new ways of working and new types of work, a better sharing of employment opportunities, development of cultural, social and recreational occupations all represent a challenging field for investigation and innovation.

“Voiceless” growth: even though two-thirds of the world’s people may now live under formally democratic regimes, too many people are still denied even the most basic forms of democracy. Moreover, past episodes in some rapidly developing economies have shown that workers’ rights can be ignored even when incomes are rising rapidly and are fairly equitably distributed. Democracy, therefore, has to be combined with development and a fair distribution of growth products.

“Futureless” growth: today’s economic growth consumes its very natural foundations, squandering resources needed by future generations. Third world countries are particularly affected by attrition of their resources to the benefit of the developed world and/or by their own consumption of non-renewable energy sources.

“Patterns of growth that perpetuate today’s inequalities is neither sustainable nor worth sustaining,” says the Human Development Report 1996. To these inequalities in space between “two

worlds”, inequities over time are added when today consumption of earth wealth would deprive the coming generations from what they need for a sustainable development. This emerging concept of sustainability is by itself a huge domain for basic research (e.g. modelling) and applied and technological research.

“Restless” growth: violent behaviour and its health consequences - both at individual and collective level - have long been considered a matter of concern for law enforcement and the insurance companies, the health sector being concerned only to repair whatever it could. Violence is now, and rightly so, taken as a social and public health problem in which health professionals have to engage themselves with a broader scope. Special attention must be given to prevention by acting on the long-term determinants and the “precipitating factors”. This is a new field of involvement for the health sector, which will benefit from transdisciplinary research.

### 3.7 Challenges ahead

There are two contrasting ways of looking at the world situation toward the end of the Twentieth century. The first one is rather pessimistic, fed by the accumulation of many complex problems for which no clear solution appears possible. The preceding sections of this chapter have, indeed, drawn a worrying - yet not comprehensive - picture of risks, dangers, negative trends that threaten the health and well-being of individuals and peoples, the sustainable development of nations and of the whole world.

On the other hand, WHO contributed to an optimistic vision, at least in the field of health, when, in 1978, it proposed the goal of “Health for All by the Year 2000”. Even though this generous slogan was largely concerned with universal access to basic

health services, some of its components such as reduced infant mortality have been attained, while others are still out of reach.

Challenges ahead are numerous and enormous. However, we do have the potential to overcome them, provided that some prerequisite conditions are met: a political will, a mobilisation of resources, and a set of commonly accepted values. Political will should operate at various levels, from local to international. The mobilisation is essential of all available resources - material, technological and, above all, human - inter alia, the world scientific community: universities, academies, researchers, and should make optimal use of information and communication technologies to the benefit of the global village. Harnessing the power of science,

technology and medicine is the topic of the following chapter. But value systems and ethical issues, in the context of research for health, need to be discussed

here since they represent the global consciousness that is needed in order to realistically improve the current state of world health.

### 3.8 Value systems, ethical issues and research for health

The CIOMS-WHO Colloquium held in Charlottesville in 1994 under the aegis of the Advisory Committee on Health Research on the impact of Scientific Advances on Future Health, delineated important areas for investigation: basic sciences; engineering in health sciences; future perspectives on concepts of health and disease; health, nutrition and demographic trends; man made environment, health development. All indeed have ethical implications and the ethical dimensions of these issues must be worked out carefully, taking full account of their potential adverse effects.

While providing ways and means of solving major health challenges, science must help define the right balance between the protection of individual rights and the public rights, at various political levels and worldwide. Another ethical issue deals with human behaviour vis à vis health. Many health problems, especially but not exclusively in the industrialized countries, are associated with behaviour detrimental to health, at individual (risk taking) and collective (pollution, man-made disasters) levels. Other problems - either permanent and universal, such as gender discrimination, mass population displacements, or the AIDS pandemic - call for an ethical approach based on redefined societal value systems.

The new technological methods of collecting, retrieving and exploiting information facilitate the use of information but may also increase the risks of misuse. Therefore safeguards should be introduced to protect the privacy of people involved - with their informed consent - in any type of research involving human beings. Steps need to be taken to ensure the confidentiality of personal data

and protect intellectual property. Research cannot develop without confidence and trust among the researchers themselves and between them and the sponsors, subjects and users of research.

Is ethics able to help, according to a well-known saying, "reconcile science with conscience" in the field of health? Probably so if, not confining itself to medical bioethics, it becomes truly an ethics of life and health sciences. Indeed, medical ethics has experienced, in half a century, a tremendous change, evolving from the Hippocratic tradition to the development of bioethics linked to dramatic progress in science and technology and then to the concept of equity in health access and care. However, as health is more and more seen as a human right, new ethical questions arise - a critical one being how to balance efficiency and ethics in the delivery of health care in a context of shrinking resources. This question is central in the renewal of health for all strategy. More and more, ethics stands at the crossroads of science, technology, health and human development; the role of WHO is essential, if the Organization is to stand as the global health conscience. In this endeavour, the constant and confident cooperation between WHO and the CIOMS is a tremendous asset.

In their scientific approach to these various issues, researchers must indeed conform to well known principles that constitute the common denominator, or better, the humanistic core of classical ethics. However some other principles are worth considering, namely: principle of reality including realistic appraisal of facts, constraints, limits, and opportunities; principles of responsibility, vis à vis the persons and groups involved in research as well

as application of the results of research; and principles of accountability, to individuals, decision makers and society as a whole.

In spite of the specificities of and the differences between various cultures, a common core of ethical values needs to be agreed upon. For example, the Conventions - held in Chicago in - of the Parliament

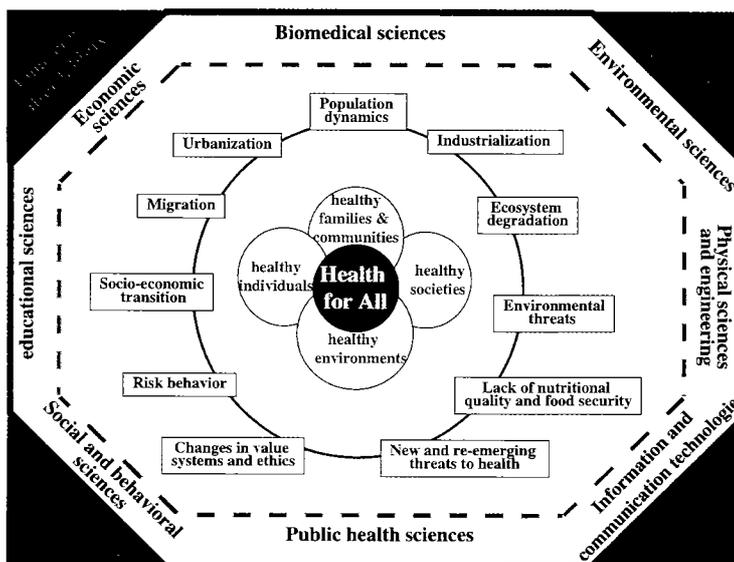
of World Religions, which was attended by more than 6,500 representatives of all existing religions from all over the world, agreed on an initial declaration „Towards a Global Ethic“ as a basic for the future development of human life on this planet. It is to be hoped that such activity will have an important influence on ways and means to attain better health for all.

# 4 Harnessing the power of science, technology and medicine

- ◆ Environmental sciences
- ◆ Biomedical sciences
- ◆ Public health
- ◆ Health economics
- ◆ Educational, social and behavioral sciences
- ◆ Physical and chemical sciences and engineering
- ◆ Systems science and technology
- ◆ Mobilizing the scientific community and partners

## 4.1 Introduction: all sciences contribute

In spite of the highly-visible advances of modern molecular biology, practice and achievements in disease control and delivery of health care owe much to a range of other sciences. The other biomedical sciences, the physical sciences and engineering, the environmental sciences, the social and behavioral sciences, the educational sciences, the economic sciences, the information and communication technologies and public health sciences, all have played a part. (See Figure 4). In considering their possible role in solving present and emerging problems of global health, it is worthwhile to take note of their contributions in the past and their potential. What follows here describes very selectively some of the ways in which they have contributed to understanding and facing health problems.



**Figure 4: Tasks and challenges for the scientific community** Evolving problems in health arise from a multiplicity of contributory factors; solving such problems will correspondingly require inputs from a multiplicity of scientific disciplines. All scientific disciplines must contribute to widening and deepening the knowledge base (see octagon), subject to irreducible criteria: social and ethical acceptability, environmental sustainability, effectiveness and validity, and affordability.

## 4.2 Environmental sciences

### **Human life in balance with its environment.**

The health of any living organism, including man, is determined by a combination of internal factors, including genetic pre-disposition, chronological and biological age, and previous history of health and behaviour, and external factors of the environment, including availability of food and water, natural habitat, presence of predators, competitors, diseases and toxic substances. This is also true for a “society” where “health” is defined by its cultural or ethnic determinants. We talk about “young” or “old” societies, “strong” or “weak” societies, and “healthy” or “sick” societies. The history of mankind is determined not only by the birth and death of individuals but also by the birth and death of societies, of groups of people, of nations. The health and well-being of any individual or of any society lies in its ability to retain a functional balance (a) among all its internal organs and systems, and (b) with the external environment.

### **Disease as failure to cope with environment.**

In this perspective, disease occurs when the organism or society exceeds the limits of its normal “coping ability”, and the balance is lost between internal defence mechanisms and the environment. Death occurs when “stress” exerted by the physical or social environments exceeds the “repair” or “coping” capacity of the individual or the society. The integrity of the human organism is exposed to continuously changing environmental conditions characterized by physical, chemical, microbial and psycho-social factors, both “natural” and “man-made” (cf. Chapter 3.1 above). Failure occurs, both at the level of the individual and at the level of society, when “coping” or “repair” mechanisms are exhausted through “disease” or are irreversibly damaged through death of the organism or death of society. What most distinguishes mankind from all other forms of life, however, is the fact that humans, more than any others, can directly and knowingly change their external environment - for better or for worse.

### **A brief history of the evolution of environmental awareness.**

The history of mankind since earliest times has been characterized by struggle with, and exploitation of, the natural environment. The quest for land, food, water and other natural resources was often a source of competition among individuals and societies, but the underlying assumption was that these resources were pristine and essentially inexhaustible. The agrarian revolution, including deforestation, changed the natural landscape, but it was the industrial revolution in the eighteenth and nineteenth centuries that really brought home the capacity of mankind to despoil the natural environment and upset the organic balance developed through millions of years of evolution. The result was a revolution in thinking about the environment and man’s role in response to it.

**The “first hygiene revolution”** occurred between the middle of the nineteenth and the middle of the twentieth century, and largely in the “North West” developed world, at least initially. It included the recognition of the relationship between infectious diseases and their causal agents, recognition of the ways and means to prevent their transmission (clean water, clean air, sterilization and other forms of basic hygiene), and development of antimicrobial agents (sulfonamides, antibiotics). Water systems were safeguarded, waste disposal was ensured, vectors were controlled, agriculture methods were improved, anti-pollution devices were installed in industry and transport, and environmental hazards were studied and became subject to social regulation. In short, the “environmental health sciences” were born and employed for the betterment of human health. But progress was slow and inequitably distributed, reflecting limitations in global vision as well as available technology.

A **“second hygiene revolution”**, and nothing less, is now called for in the face of globally significant population growth and migration, development of sophisticated new industrial methods and sciences,

including nuclear energy, and the dawn of a new age of information communication. To begin a “second hygiene revolution” it will be necessary to establish a global inventory of environmental risks relating to physical agents, chemical compounds, microbial agents, and psycho-social conditions. All relevant sciences must be brought to bear, worldwide, to assess risks of exposures, particularly those resulting from the “man-made environment”, and to develop new and innovative approaches to combat these health risk complexities. Some areas for exceptional involvement and contribution of the scientific community are outlined below.

**Human health assessment in a changing environment.** It will be important to improve existing methods and to develop new tools to elucidate the mechanisms by which environmental changes correlate with, or are causally linked to, the health of individuals. These mechanisms need to be understood at the molecular, cellular, cell-system, organ and organism level applicable for different living conditions, age groups and cultures. Examples of globally significant research issues include:

- improvement of existing methods and development of new tools for long-term monitoring of health in human beings in relation to the “environmental exposure inventory” utilizing a variety of methods at different levels of biological organization;
  - development and evaluation of bioindicators to detect prepathological changes and to monitor reversibility and/or irreversibility;
  - toxico-kinetic and dynamic studies on environmental effects on homeostasis in relation to dose, dose-rate and the kinetics of complex chemical interactions;
  - assessment of dietary requirements and health-related behavior (life-styles);
  - development and use of remote sensing technologies to analyse and predict probable detriments to human health.
- Global environmental epidemiology** must attain a new dimension, using standardized epidemiological and biomedical methods. The issue is to study the environmentally induced changes in human health that can be linked to changes in ecosystems and associated with ambient environmental exposure. Possible research activities include:
- conducting case studies using risk assessment models;
  - conducting studies on sensitive sub-populations (e.g. children, pregnant women);
  - evaluating health effects of environmental pollution and contaminants;
  - defining the potential of including environmental and biological indicators or the development of analog systems for remote sensing;
  - development of new technologies to detect effects of exposure and repair more rapidly and in more details;
  - studying the molecular biological mechanisms relevant to risk assessment;
  - development of appropriate indicators to describe exposure and effects of complex mixtures;
  - conducting comparisons of occupational vs. non-occupational risk assessment methods.
- Eco-system dynamics in relation to human health** is another important area for study. The research to be done should include such topics as:

- evaluation of temporal variations at the ecosystem level considering interaction of climatic, hydrological and biological factors;
- determination of transport among the compartments (interactions, sinks of chemicals);
- documentation of species composition and diversity as a function of time and exposure conditions;
- description and analysis of food chains and changes thereof considering the distribution and trade routes around the globe.

**Integrated chemical and biological monitoring** is of importance to better understand the global status of environmental pollution of land, air, water and food in relation to the distribution dynamics of, for example, toxic chemicals and radioactive particles that “migrate” around the world. This suggests possibilities to:

- establish a network of integrated exposure measurement stations around the world;
- develop a human biological specimen bank (for example: to collect subcutaneous fatty tissue removed during surgical interventions in order to study toxic agent transport);
- investigate new approaches for establishing worldwide networks in the following areas: systems theory and analysis, environmental chemistry and medicine, eco-system research, remote sensing;
- develop robust methodologies and approaches for screening against pollutants and toxic substances.

These novel approaches call for new efforts and initiatives in the engineering, physical, chemical and biomedical sciences (see below). It is essential to develop not so much a “high-tech” or “low tech”

tool as to develop “intelligent” and appropriate instrumentation to monitor the environmental dynamics in relation to human health and the “health” of the eco-systems themselves.

**Complex systems research in environment and health** will be needed, including the development of models using advanced computer technology, and means of scenario development, risk assessment, “meta” knowledge, as well as information and communication processing technology (See also 4.8 and Chapter 6 below). Typical areas for such systems research include:

- modelling of material and energy flow at a global level;
- modelling of growth and death processes for example in agriculture (fertilizer problems and ground water) and dynamics of growth of towns or industrial complexes in relation to eco-systems, population growth and human health;
- understanding of feedback phenomena including the potential and danger of uncontrolled development in food production;
- modelling for global and regional planning with emphasis on the devastating effects of further overpopulation;
- evaluation of economic, toxicological or epidemiological factors of world-wide importance.

The ideas outlined above offer the beginnings of a “second hygiene revolution”, not as it occurred in the last century, but as a revolution of global dimension using all available and relevant scientific tools and intellectual resources, which may in the end constitute new “repair” and “coping mechanisms” to ensure the health of all mankind and our planet Earth. Some outstanding research imperatives addressing specific issues of health and the environment are outlined in Chapter 5 below.

## 4.3 Biomedical sciences

### 4.3.1 Dealing with infectious diseases

Modern biomedical science owes its roots to at least two extraordinary insights. The first was a recognition by Darwin and Mendel of the essential unity and relatedness of all forms of life, and their evolution by hereditary transmission, variation and natural selection. The second insight was the concept of the aetiology of infectious disease, promoted by the discoveries of Pasteur, Jenner and Koch, that each infectious disease can be traced to some specific pathogenic entity, a different species of micro-organism, that can be addressed by medical science. The idea was to “find the bug and stamp it out”. (This “germ theory of disease”, without question one of the greatest single discoveries ever made, was enunciated not by a physician, but by a chemist). These revolutionary discoveries arose out of observations that did not fit prevailing scientific doctrine, and required re-examination of scientific concepts, but they opened the door to the “microbe hunters” and to the development and improvement of “magic bullets” in the form of vaccines, sulpha

drugs and other chemotherapeutic agents, vector control chemicals, antiseptics and eventually antibiotics. Progress was by no means linear, and, as in the case of Fleming’s discovery of penicillin, in those early times most important drugs were discovered by a combination of serendipity and empirical observation by prepared minds. The science of pharmacology and the modern pharmaceutical industry were born. Public health had, albeit still primitive, new weapons to deal with bacterial, viral and other diseases. These have included: smallpox, tuberculosis, cholera, dysentery, typhoid, pneumonia, syphilis, gonorrhoea, puerperal fever, scarlet fever, meningitis, diphtheria, poliomyelitis, measles, pertussis, tetanus, typhus, hepatitis, influenza, malaria, schistosomiasis, filariasis, trypanosomiasis, leishmaniasis, leprosy, dracunculosis, Chagas’ disease, yellow fever, encephalitis and rabies. The list is essentially inexhaustible.

### 4.3.2 Race against the bugs

Perhaps the biggest success ever achieved in health care was the prevention of diseases through mass vaccination. Vaccination of the population world-wide led to the eradication of small pox, and poliomyelitis will be no doubt the second disease to be eradicated at the dawn of the 21st century. It is true to say that vaccination programmes in countries in need have greatly contributed to the well-being of their populations. New concepts will provide vaccines against viral infection, (such as dengue and human immunodeficiency viruses), as well as against bacterial and protozoal infection (such as tuberculosis, schistosomiasis and malaria) that as today are the main causes of death world-wide. Research is also under way to provide vaccines in

the future for the control of non-communicable diseases, such as diabetes, cardiovascular disease and certain cancers (such as cancer of the uterus, cancer of the liver, Kaposi sarcoma). Genetically manipulated nutrients such as potatoes, bananas and corn, that carry a vaccine will give ways to overcome major constraints in the vaccination of large populations.

The enormous arsenal of drugs, vaccines and means of application against infectious diseases have thus been constantly widened and improved in recent years, but the microbes have not taken it lying down. The chief disappointment in the accelerating “race against the bugs” has been the rapid rise of resistant

strains of microbes to the point that we now face a rapid failing of our repertory of antibacterial antibiotics and the risk of a virtual desert of chemotherapeutics for viral infection. The second concern has been the emergence or re-emergence of infectious diseases. These include the current, world-wide AIDS pandemic, haemorrhagic fever such as Ebola, Marburg, and Lassa fever, a rising tide of iatrogenic or hospital infections and cases of transmissible spongiform encephalopathies (“prion” diseases). A current nightmare scenario would be a revisit of the lethal influenza pandemic of 1918 which claimed 25 million lives, more than all those lost in World War I. Such a possibility underlines the importance now of developing strategic systems for world-wide surveillance, detection and response to new and re-emerging microbes, newly drug-resistant organisms, evolving vectors, and new contacts with zoonoses.

This is all the more necessary where the dynamics

### 4.3.3 Dealing with “constitutional” disease

Just when reasonably adequate means of controlling the known infectious diseases appeared to be more or less in hand, roughly by the time of World War II, the battlefield widened to what might be called the “constitutional” diseases, including non-communicable, hereditary and/or “chronic” diseases. These conditions have only one way to go in view of demographic change, longevity, environmental effects and so-called “affluent” lifestyle. They were recognized first in the developed world, and then in the developing countries, which then shared the “double burden” of both worlds. The “constitutional” diseases raised the still more difficult problem of trying to deal with the complexities of the human host. Where questions such as cancer, heart disease, toxic illness, hereditary defects and mental, behavioural or social disorders arise, the proposition is not so simple as “locate the bug and stamp it out”. Trying to drive a wedge between a tumour and its host is intrinsically far

of the free market would not necessarily lead to the technological developments, adaptations and cost reductions needed in developing countries. For example, in many cases vaccines are still insufficiently adapted to the requirements of developing countries. For this reason, WHO is encouraging the improvement of existing vaccines, to obtain greater heat stability, single dosage and/or oral delivery, with improved efficacy, and aimed at diseases that most affect the developing countries. Furthermore, WHO programmes such as those for vaccine development (GVI), tropical disease research (TDR) and human reproduction research (HRP) stress research performance and institution strengthening in the developing countries, and WHO utilises a network of collaborating centres, research institutions and other partners in virtually every country of the world. But the “race against the bugs” like the overriding quest for Health for All, is endless, and can never be won once and for all. The winning, therefore, must be in the running.

more difficult than trying to do that between an alien microbial invader and its host. It has taken a very long time to begin to do it. During that interval, a great deal of progress has been made in basic understanding in the biomedical sciences, and in various clinical applications, such as radiation medicine and chemotherapy against cancer, albeit mainly in the empirical mode. In large screening programmes based on limited “rationale”, it is difficult to predict which chemical compound is going to work. One learns *ex post facto* that some things work better than other, but one cannot operate with confidence from any theory that can predict the next step. Nevertheless, this situation has gone through yet another basic scientific revolution, one that now offers enormous potential for the Twenty-first century’s campaign against the human “constitutional” diseases as well as the “war against the bugs”.

#### 4.3.4 Revolution in molecular biology and genetic science

The breakthroughs that have led to this new phase of advancement in the life sciences through understanding of the genetic basis of life, started emblematically in 1944 with Avery's discovery that an extract of one pneumococcal type could alter the serologic character of the cells of another, and that the source of this genetic influence was an unsuspected molecule, deoxyribonucleic acid (DNA). Subsequently, Lederberg showed that viral genomes could become permanent parts of cell genomes. The year 1953 saw the revolutionary Watson-Crick model of DNA structure as a double helix, making it possible to explain how a chromosome may duplicate itself in the process of cell division and transmit instructions for successive generations of living cells - the basic mechanism operative in microbes and hosts. Molecular biology and genetics received an enormous boost from that

breakthrough in understanding. The knowledge of the role of DNA as the central storehouse of the blueprints of the cell was, and is, the key to how to approach questions of the distinctions within the human organism and its cells which can be used for therapeutic advantage. The first clinical application of this knowledge was the development of diagnostic procedures for the prenatal diagnosis of sickle-cell disease and thalassaemia. Since then we have seen a veritable explosion of new knowledge and the renewal of rationally based therapy, using new gene manipulation techniques and using new drugs designed not with perfect predictability but rather founded on some specific theory of the nature of the interaction of the chemical entity with the targets, the receptors and the cell they are supposed to address.

#### 4.3.5 Human genome and the concept of disease

At the "Big Science" level, the ongoing Human Genome Project (HGP) is a global initiative to "map" the human genome by defining "marker regions" and to define the DNA sequence of the some 90,000 human genes. Success depends on the interplay of life sciences with many other disciplines and technologies, including automation, robotics and informatics. There is a consensus that the derived genomic information is in the public domain, open to the enquiring public, and to be made available to the entire scientific community. With some 450 diseases for which specific genetic bases have been identified, and with the human genome now substantially mapped, molecular genetics is undoubtedly one of the most successful scientific enterprises ever launched in the life sciences. Together with the advances in the molecular biology of the cell, it has a profound impact on clinical medicine. An increasing number of diseases can be defined and classified in molecular terms which

sometimes make previous clinical distinctions obsolete (as is the case, for instance, within the group of neuromuscular disorders). The emergence of molecular genetic classification of large groups of diseases, and the concomitant availability of genetic diagnostic tests, raise the possibility that the entire taxonomy of human disease may be revised in the near future. Predictive diagnostic testing in clinically asymptomatic individuals will become increasingly used. Besides the serious ethical questions about the access to and use of such information, a problem to be faced is that for large segments of society, including health professionals, the concept of disease may become synonymous with the carrier state for a particular set of genes. Such "genetic reductionism" may have serious practical and ethical consequences in areas such as health and life insurance, employment and, ultimately, human rights. There is a clear international consensus promulgated by the World Health Assembly in 1997

that use of cloning to replicate human individuals is forbidden to scientific research. Nevertheless, the ability to clone living organisms including animals

raises further issues and opportunities for public health.

#### 4.3.6 Major applications in public health

The forthcoming applications of molecular biology and genetic science for diagnosis, treatment and prevention of disease are legion. Molecular biology has given rise to a new science of molecular epidemiology. New knowledge of the immune system and immune response opens the doors for new designed drugs and vaccines to boost immunity to a host of infectious and chronic diseases. Molecular genetics has greatly increased our understanding and has begun to provide means of therapy for a number of “monogenic” diseases such as cystic fibrosis, where there is a single gene defect, to “polygenic” and complex disorders such as diabetes, atherosclerosis and essential hypertension. DNA offers a new principle, measuring predisposition to disease, early diagnosis and

prognosis of the cause of illness and recovery. Mass screening for disease, genetic disorders, and environmental impacts are now feasible. New and reliable methods are available for DNA identification, blood safety, human organ transplantation and xenotransplantation using animal tissues. Medical genetic counselling has new tools and means of application. Developmental biology techniques offer new means of fertility control for family planning and infertility treatment. Neurosciences are benefited by new possibilities for understanding and treating muscular dystrophy, Down’s syndrome, Parkinson’ and Alzheimer’s disease. But perhaps the greatest impact of all will be in the field of oncology.

#### 4.3.7 Dealing with cancer

The war on cancer is entering a new phase with a better understanding of the mechanisms of oncogenesis and new gene-based drugs that will challenge conventional treatments. The effects of environment, toxic, exposure and nutritional (for example the role of free radicals) are better understood at the molecular and cell function levels. Unlike chemotherapies, the new drugs are biological, based on naturally occurring proteins or genetic materials. The new biotherapies are highly specific in action, focussing on specific cells, molecules or genes, and unlike most chemotherapies, they have little or no toxic side effects for the patient. Many will be shortly entering the market for public health and private clinical use. A monoclonal antibody for non-Hodgkin’s lymphoma will soon be available. Another

monoclonal antibody is in clinical trials for advanced metastatic breast cancer. These monoclonal antibodies consist of genetically engineered copies of the proteins that are the immune system’s normal front-line defence. They focus on proteins that cause and maintain the neoplastic process. **Therapeutic vaccines**, consisting of fractions of human cells that trigger immune response are under study. One of these vaccines for melanoma is expected to soon be on the market. Another approach is “**anti-sense**” **drugs** that work on genes within cells to neutralize the “messenger” RNA that prompts cells to produce proteins that cause unregulated replication of cancer cells. “Anti-sense” drugs offer the promise of “switching off” cancer-causing genes. But some cancers are caused by the opposite problem: a deficiency of natural tumour-

suppressor genes. Gene therapy offers the possibility of injecting DNA into human cells, to replace damaged genes or produce proteins that stimulate the immune system, and also to enhance chemotherapy by sensitising cells to drugs. For example, a gene therapy regime is now under clinical trials on patients with lung cancer and on those with tumours of the head and neck, to augment a “*p53* gene” that is often deficient in cancer patients. Also, in advanced clinical trials is a gene therapy for inoperable brain cancer. This therapy causes the tumour cells to produce a protein that makes them susceptible to chemotherapy. Inserting

whole genes into cells is difficult, so most techniques rely on some form of carrier, such as a genetically modified virus. A virus has been developed, without a gene attached, that selectively infects and kills only cells that are deficient in *p53*. Yet another approach is a treatment for melanoma using injection of “naked DNA” without a carrier virus. Techniques based on non-viral vectors (e.g. lipoplex delivery systems) are also under study. The search is now on to attain the “gold standard” in chronic disease treatment: a small-molecule drug that can be given in pill form.

#### 4.3.8 Interactive disciplines

In renewing “Health for All”, the world has set for itself the evolving goal of overcoming the most burdensome diseases and conditions of ill health, and promoting the fullest possible health - in short, the attainment of public health. Central to this effort are the contributions of the life and health sciences, which depend in turn on other branches of knowledge. A vast area of challenge for the interdisciplinary approaches that are the hallmark of the “new public health” is how to put the full range of life, health and allied sciences at the service of the greatest number of human kind - both as individuals and as vulnerable population groups. The core discipline of public health continues to be epidemiology, but its meaning, methods and applications now extend beyond the purely “epidemic” diseases to all human diseases, infectious and chronic, and to all determinants of

ill health, from poverty to environmental degradation. Epidemiology draws upon and guides a wide range of other disciplines, scientific research and interventions that serve public health. In the war on disease and ill health, every one of these disciplines must be invoked. They include, among others: the earth sciences, physics, mathematics, engineering, electronics, nuclear science, physical chemistry, biochemistry, molecular biology, cell biology, microbiology, genetics, toxicology, zoology, physiology, psychology and other social and behavioural sciences. Today, historically and for the future, none of these scientific disciplines can stand entirely alone; they are mutually dependent, each building on and contributing to the other. The challenge is to harness them still more rapidly and effectively for the public good.

### 4.4 Public health

Public health is not a discipline or a science by itself. It is a broad domain where various disciplines meet and cooperate, mixing their scientific knowledge and advances into a cross fertilization process. Its main characteristic, which distinguishes

it from clinical medicine, consists of its focus on population at large, at various levels, from nations to groups of people linked by some common features. These may include geographical area, living conditions, socioeconomic and cultural

characteristics, occupation, common health problems, diseases, or health impairments. Some of these groups can be described as “captive populations”, such as mothers and infants, school children, workers in a given enterprise, institutionalized persons and the elderly, thus facilitating epidemiological surveys within the defined population groups.

From its very beginning, public health has been concerned with classical hygiene designed to prevent the spread of communicable diseases through physical and chemical containment or elimination measures within countries. Early on, there developed initiatives in international co-operation for containment of diseases in the form of the “cordon sanitaire”, starting with quarantine for travellers and immigrants. Several international conferences were organized on this subject, from the second half of the XIXth century through the First World War. Then the Committee of Hygiene of the League of Nations took over, succeeded by the WHO after the Second World War, with increasing emphasis on the prevention and control of endemic diseases and conditions of ill-health. Step by step, the scientific bases of public health were developed and diversified.

Sciences contributing to public health may be characterized as “quantitative” or “qualitative”. To the first category belong: (a) statistics, especially health and health related statistics; (b) demography that offers the profile of populations under studies as well as the denominator needed for calculating rates; (c) epidemiology, the core discipline of public health with its three varieties: (1) descriptive, (2) analytic, and (3) explicative or evaluative; and (d) economics, with its specific branch of health economics.

The qualitative disciplines contributing to public

health are many, belonging to the huge field of human sciences. The main ones include sociology, human anthropology, psychology, law and ethics. This distinction is open to question: for instance, where to classify the environmental sciences which play an ever increasing role in public health? Nevertheless, what is important is to combine the specific inputs of these various sciences in public health development.

Reconciling these qualitative and quantitative sciences - and scientists - is a prerequisite for research in the many fields of public health. From its origin, public health has focused on environmental problems, from individual housing to the state of the planet as a whole: sanitation, pollution in all its forms, and waste management, whose health aspects are more and more at stake. The science of environmental engineering is concerned with basic and applied research on the adaptation process between human beings and the milieu.

Public health, as it applies throughout the life cycle at individual, family and community level, embraces action and research on human reproduction, maternal and child health, adolescent health, occupational health, and health of the elderly. This is the field of social medicine, which is the meeting point where “medicine, science, and public health must merge for the greater good”<sup>4</sup>. Research on behaviour, either conducive or destructive, to health, including diet and “lifestyles”, is central to the public health approach. Poverty, as a fundamental determinant of ill health, is itself an important field for social research, drawing on sociology, economics and other human sciences. The strategic objective of the Research Policy Agenda for the Twenty-first century must be to put everything from the most fundamental experience to the most sophisticated science at the service of the most people.

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<sup>4</sup> Lederberg, Joshua. Address at the UC Berkeley, School of Public Health, May 11, 1996.

## 4.5 Health economics

The pursuit of health promotion, health care and other health strategies requires the input of scarce resources. Economics, business administration and management are the major sciences of the optimal use of scarce resources at different levels. These sciences must be considered when working towards health development. In their specific reference to health, they can be summarized under the label “health economics”.

In the perspective of global health development, health economics comprises three major areas of work: economic evaluation of health oriented technologies, the economic analysis of health care systems, and the management of international and intersectoral health problems. Potential, limitations and research needs of health economics in these three areas will be dealt with in the following.

### 4.5.1 Economic evaluation of health oriented technologies

Economic theory has shown that in the field of commerce and industry free markets are an organizational form that normally leads to an efficient allocation of resources. In a nutshell, this means that goods are produced with a minimum input of resources (technical efficiency) and that just those goods are produced which the consumers are willing and able to buy (allocative efficiency). It is open to question, and thus to further research, the extent to which these concepts apply in the field of health. Many health systems, however, have non-market features, as for example the provision of compulsory health insurance covering a defined package of services. The efficiency of a number of health oriented measures remains unclear. Information on efficiency is therefore needed by decision makers. Economic evaluation studies can provide this information (this type of analysis is also known under the terms health care technology assessment and medical technology assessment; technology assessment, however, also covers the evaluation of other than economic aspects of technologies, for example ethical aspects). Economic evaluation means to analyse the cost of a measure or technology as well as the effects of it. Cost-effectiveness analysis looks at an individual effect dimension, cost-utility analysis at valued health states (for example, in terms of quality-adjusted life years,

QALYs), and cost benefit-analysis at effects in terms of money. Economic evaluation is a methodology that can be directed at the analysis of medical interventions, of public health interventions, but also of developmental measures such as an educational program. In medicine, the development towards evidence-based medicine over the last years has often been complemented by such economic evaluation studies. This scientific trend, underlined by several thousand studies available in all different fields of medicine, requires current medicine not only to prove effectiveness, but also cost-effectiveness of new technologies. A similar challenge can be assumed for public health interventions or other health-oriented strategies. Economic evaluation studies provide information for decision makers, but do not claim to determine the decisions: the use of this information heavily depends on the organization of decision-making power in health systems and the incentives set for decision makers. Often, political decisions with respect to which cost-effectiveness is acceptable and which one is not are required. The alternative to the production and use of cost-effectiveness information is, however, to take uninformed decisions. Because resources are scarce, health development strategies must face the challenge to show that they are cost-effective.

#### 4.5.2 The economic analysis of health care systems

There are hundreds of different health care systems on this planet, and they are constantly changing with ever new reforms. A health care system consists of the market for health services and of the market for health insurance, with many options to organize and link the two markets. Three basic types of health care systems are the national health service, the (compulsory) social health insurance system, and a pure market system based on private health insurance. More recently developed options are managed care organizations such as health maintenance organizations and social security systems with competing health insurers and risk adjustment mechanisms which are to assure access for bad risks (old and multi-morbid citizens).

In economic terms, the common goals of all health systems are to achieve effectiveness and efficiency (as defined above), equity and solidarity (for which no general definition exists) and cost containment (which means to constrain the secular growth of collectively financed health care expenditure). The economic analysis of health systems is the science of which forms of organization of a health system achieves these goals to which extent. Microeconomic analysis tackles the behavior of individual actors - for example, doctors, hospitals or patients - in the system, macroeconomic analysis is required when it comes to the relevance of health care expenditure in the development of the national economy (this does not only include issues such as labor costs, but also employment opportunities).

Health systems, but especially health care expenditure is very closely linked to the economic development of a country. While the least developed countries typically lack a fully organized system, a certain level of economic development allows countries to introduce and build up social security

arrangements. Economic growth nourishes further extension. Rich countries with widely established health systems and significant interest groups in these systems often suffer heavily from the enormous growth of these systems, which require increasing shares of the gross domestic product. In a global perspective, the economic development of countries over time requires thus an ongoing adaptation of the health systems to the preferences and economic possibilities. The choices in these adaptation processes can be informed by economic analysis. The dynamics of health systems is primarily economically determined, but is also determined by factors such as demography. Population growth in poor societies increases, among other needs, the needs for health promotion and health care. Economically well developing societies, however, often face a decline of mortality rates and a later decline of birth rates, which increases the share of the elderly and especially the dependency ratios (children and elderly/working population). This phase of demographic transition can create severe problems in the financing of health care, where total expenditure for the whole population typically has to be financed by the - shrinking - working population. The phenomenon is relevant to many industrialized countries today, but can be seen to emerge in a number of fastly developing countries.

According to this situation, there is a continuous need to analyse, evaluate and eventually reform each individual health system. Given this, the comparative analysis of different systems and the comparison of experiences on a global scale are obvious research needs for the future, where much can be learned and gained by the international exchange of information.

### 4.5.3 The management of international and intersectoral health problems

The fight against tobacco and smoking, or the global fight against AIDS are examples for comprehensive health strategies. These strategies touch the health system, but also may have implications on demography, the national economy, certain industries, and other societal domains. These issues feature the characteristics of intersectorality, and often are only to be tackled in a global perspective. The economic aspects of such strategies and their management form a third area of health economics which is relevant to global health development. The respective analysis requires combinations of economic evaluation and systems analysis as well as the use of management techniques.

Health economics can provide the tools for these types of analysis. There are the evaluation and analysis techniques outlined in the above two sections. These tools can be complemented by additional methodology. For example, scenario modelling techniques describe alternative future

developments. Management processes can elaborate economic detail, especially on costs, effects, organisational setting, financing, and evaluation. Such management processes extend and specify, economically, the traditional management cycle of planning, implementation and evaluation. They can be used for complex problems. The analysis of the combination of various systems with the health system, the exploration of future development and the economic analysis of choices in the management of these problems form the core of this new, challenging research area.

Other examples of problems that fall under this new domain are interaction between migrations and health, the relevance of alternative developmental strategies for health, the correlation between economic development, hygiene/sanitation and health, and economic environmental strategies and health issues.

## 4.6 Educational, social and behavioral sciences

### 4.6.1 Education

Imparting knowledge and understanding, and developing the skills of its people, through education is a fundamental imperative of government. Education contributes to maintenance and improvement of health, social cohesion and economic development. While increasing the availability of basic education - even improving the dissemination of knowledge to professional workers - is a recognisably desirable goal for any country, it is costly. However, other options are now available.

It has been said that “shipping electrons around the world is cheaper than building schoolrooms”. This is not to undervalue the primary importance of schools. But it does highlight the great potential

value to developing countries that modern communication technology makes it possible to establish “distance education” networks, nationally and internationally. “Distance education” means: the provision of educational and training services to persons who cannot visit regular educational institutions by reason of location, distance or time constraints. Using distance education networks, the educational infrastructure of industrialised nations can, in principle, be utilised in a cost-effective manner by developing countries to implement educational systems which will match the best standards of the developed countries. Tapping the educational resources of the world in this way will allow developing countries to close the gap with

developed countries in the field of education.

Distance education, as a global undertaking between developed and developing countries using currently available communication technology, can be an efficient way to advance primary, secondary and university education world-wide. Many opportunities for personal growth and job mobility can result. It allows the work-force needs of industry to be met by providing continuing and advanced training for employees, which will enhance productivity. It also allows professional groups such as health sector workers to refresh and update their knowledge. In sum, the use of distance education technology offers the chance to reduce the educational gap between developed and developing countries and to avoid the loss of further opportunities for economic growth and development and their impact on health.

Three kinds of approach have been developed by educators. The “Distribution: Out” approach provides informational programmes designed

primarily for “off site” education and training. The “Access: In” approach provides access to the existing educational services of an institution, such as library resources, scientific data and current data banks. The “Exchange: Between” approach provides access by the participants to individuals and to centres of excellence, regardless of location, affiliation or subject area. Each approach has its special educational “technology”, developed to take advantage of the opportunities and limitations of the specific approach. The technology currently employed depends on the style of possible communication. Where “synchronous” communication is feasible, in real time, between teacher and student, the methodology employs: a “travelling educator” visiting various locations away from the “home institution”; one-way video with two-way audio; two-way video and audio; or two-way audio, “chat-lines” and the Internet. Where “asynchronous” communication is necessary and direct person-person exchanges do not occur, the technology may use: books, CD-ROM, electronic mail or post.

#### 4.6.2 Social and behavioural science

Health status depends not only on biological aspects but also on a broad range of other factors that clearly influence health, such as nutrition or the physical environment. Factors of socio-economic origin are not well understood, but relevant questions can readily be defined. For instance, how does the social environment affect health: including the effect of social or domestic violence, civil disturbance and wars, population displacement and “borders”, urbanisation, unemployment, economic migration? In helping to answer these questions the social and behavioural sciences offer significant opportunities for global health development.

Human health is intimately bound up with human behaviour, in risking or damaging health, in promoting health, and in the motivations that influence the decision whether to seek health care

and the decision whether to accept it. This applies not only at the individual level. Peer group pressures specifically, and social pressures generally, can “propagate” amongst groups various life style risks such as smoking, almost as if these were communicable in the usual sense. Road traffic behaviour affects accident rates and causes. Even the way in which personnel within organisations interact one with another in carrying out their duties reflects behaviour that influences the overall performance of the organisation, such as a health system. Behaviour patterns and motivations are relevant to the acceptability of public health programmes - such as community-wide immunisation of infants, fluoridisation of water supplies in order to reduce dental caries, legislating about wearing of seat belts in cars.

Much attention has been devoted to these issues recently - to the benefit of health of the community at large. A particularly urgent need is to understand

the motivations for health-damaging behaviour and what would motivate individuals and peer groups to adopt health-promoting behaviour.

## 4.7 Physical and chemical sciences and engineering

The scientific and technological scene is developing rapidly. Apart from molecular genetics and biotechnology, many other new diagnostic and therapeutic possibilities are emerging. For instance, new therapeutic possibilities come from laser technology, the biophysical development of "designer" pharmaceuticals and other biologically active macro molecules (e.g., proteins), and the use of new materials for internal or external prostheses in rehabilitation. Basic science is illuminating brain function with the aid of positron emission tomography and associated technologies, offering the hope of understanding more about the degenerative diseases of the elderly. Information technology allows the effective gathering and utilisation of public health information; modern computing technology and the use of computational logic provides new opportunities for system modelling and for the use of advanced decision support at all levels from PHC to national planning for both design and management of health care delivery systems. But the potential of such advances should not be allowed to overshadow the fact that much existing capability in health care provision is due to earlier work in physical and chemical science and technology.

The classic example of an important contribution to health care from research in physical science is X-rays, used for diagnostic purposes and later, for treating malignant disease. Subsequent research and development has led to major advances in both applications and opened up new uses. Nuclear radiation of increasingly high energy, generated by a variety of types of device, has been extensively used for the treatment of localised malignant disease. More recently, laser radiation has also been found

to be useful in treating localised malignancy; furthermore, it has been found to have more extensive applications, sometimes in conjunction with flexible fibre optics to direct the beam: in treatment of cataract and other ophthalmic conditions, as well as in general surgery, in place of diathermy, and also in clinical measurement (e.g., of blood flow).

A range of new principles and devices has been developed for medical diagnostic imaging and visualisation. The result has been to allow excellent visualisation of internal structures and organs within the body and to transform the task of identifying many disease processes from an indirect to a direct operation. Visual insights are relatively easy to interpret, which has been a major factor in the wide use of these methods. The utility of X-ray machines was initially enhanced by use of the tomographic principle (to visualise structures in a plane within the body); the value of X-ray imaging was subsequently transformed by computer power through the development of computer-aided-tomography to achieve 3-dimensional reconstructions. Magnetic resonance imaging (MRI) is also an effective tool for visualisation and has the advantage of not exposing the patient to ionising radiation. But while these recent developments are highly effective in the screening of individual patients, they are still too costly for widespread use, especially in developing countries. On the other hand, imaging by various ultrasonic techniques is much less costly, if rather more limited in performance, although image enhancement using computer based image processing techniques has increased the capability of these methods.

Visualisation of a different kind has utilised X-ray crystallography to help determine the structure of complex biologically active macromolecules. This methodology has been the forerunner of recent advances in therapeutic drug design. Insights arising from research in physical chemistry into the way biochemical reactions occur, and the role of surface binding phenomena at the molecular level, have made it feasible to design and synthesize novel drugs, enzymes and vaccines. The design method is to provide these materials with appropriate molecular “patterns” that, due to complementarity of shape, bind competitively to macromolecules on or in target cells or organisms. The technique depends heavily on computer-aided analysis of 3-dimensional molecular structures. New protective and therapeutic agents are already becoming available from these developments.

Turning to public health engineering, improved sanitation is recognised to have been responsible for a substantial reduction in mortality and morbidity due to communicable diseases in developed countries during the last century; it is a source of concern that the number of people globally without access to safe water and sanitation is still increasing. Nevertheless, public health engineering is still a major force, and could be more so, in the prevention of disease; continuous improvements in waste water treatment and environment control, in water quality testing, as well as in distribution can be identified up to the present time wherever resources are adequate. Even in such areas, modern technology has had an impact. For instance, the control of waste water treatment plants can be optimised with the aid of techniques drawn from artificial intelligence; and simple, inexpensive biosensors (which combine microelectronics, biological “recognition” using enzymes acting as biochemical catalysts, and membrane technology) have been developed to identify the presence of pollutants, for example *E.coli*, in water sources.

Geography and the earth sciences have also contributed to an understanding of the influence of

the environment on health and of how to plan interventions. Naturally occurring radon gas leads to radiation exposure, the distribution of trace elements and toxic components and prevailing meteorological conditions are all physical environmental factors that affect health. The habitats of insect and animal species that interact with man, directly or indirectly, are also relevant. The study of such factors that affect human health has become a formal area of expertise known as medical geography and spatio-temporal epidemiology (how diseases are distributed in space and time) owes much to techniques drawn from mathematical statistics and communication signal and pattern analysis.

While new materials are widely used in care of the individual patient, both in dentistry and in surgery, they also have a role in a wider domain. In rehabilitation, for instance, new materials allow flexible design of strong lightweight external prostheses which could be easily fabricated; in conjunction with the use of recent insights into the dynamics of limb movement, the production of individualised external prostheses and orthotics should be made much simpler. Again, industrial production techniques have resulted in a wide range of inexpensive plastic aids for the disabled. Successful attempts have been made to develop “artificial blood” using non-haemoglobin based materials. Further development to allow large-scale production of such materials could help to solve a global problem. Plastic replacement materials for soft tissue reconstruction have been produced; perhaps of wider potential, biologically active materials which will bind to form tissue substrates that can be used for wound filling and covering have been available for some time.

One of the successes of industrial health care technology is the large-scale production of cheap disposable, sterile materials such as bandages, syringes and other routine medical supplies, and of cheap disposable biochemical strips for testing body fluids (e.g., for glucose level). At a more

sophisticated level, many microelectronic devices have been produced for health care purposes: e.g., medical equipment which has consequently become more widely available in the tertiary care environment and, in the context of primary health care, biosensors for measurement of constituents of body fluids and even hand-held computer-based devices for aiding diagnosis and the choice of treatment. Correspondingly by, the introduction of microchip components in clinical biochemical laboratory devices has greatly improved capability and quality in hospitals the world over.

Since decision-making and the choice of actions depend on adequate, reliable information, information technology is at the heart of much activity directed to the needs of health. Capturing comprehensive information about the need for health

care provision in different geographic, demographic or social sections of a community is difficult even in developed countries; organising the information in a form that makes it readily interpretable by health system planners is even more difficult. Advances in computer-human compatibility, in analysis procedures, in informative displays, in methods of collaborative working and in decision-support generally are reducing the cost and improving the usability of computerised systems and extending the support they can offer to planners and other public health personnel. However, there have been some failures in the attempt to use information technology in both developed and developing countries, and the socio-cultural environment must be fully taken into account if information technology is to be successfully implemented.

## 4.8 Systems science and technology

Systems science deals with the identification, spontaneous behaviour and response to interventions, of self-contained assemblies of interconnecting components. These assemblies may take the form of physical or biological structures, or of behavioural societal or economic elements. A chemical process plant is a typical industrial process system, which can be treated, in the first instance, as self-contained. The cardiovascular system is a well-defined physiological structure that can be treated as a system, though in this case of course, the system is subject to interactions with other physiological systems. The interacting assembly of behavioural activities (or indeed of societal or economic activities) in a community also constitutes a system, although difficulties arise in identifying the elements, and the pathways and indeed the nature of their interconnections - a problem that appears much more acutely in defining and studying the multisectoral determinants of community behaviour, especially for health development purposes.

The reason for approaching such structures in this way - defining the system and specifying its elements and their interconnections - is to achieve an improved understanding of both the spontaneous behaviour of the system and the nature of its responses to disturbances and interventions. To make possible the study of system behaviour it is necessary to model the system, identify the components and their interconnections, assign quantitative values to all pathways and finally simulate the system in some convenient way - say in a computer model. Naturally all this can only be achieved on the basis of adequate measurement and interpretation of real data from the system to be studied: unavoidably a complex operation. Consequently various simplifying approaches may be taken, which are justified by expediency or by practicality. An example is the use of a static model, based on a path-analytic analysis; using a static model disregards the dynamics of the system altogether and sees the system only in terms of steady state conditions; path-analytic analysis

disregards the complete feedback loop nature of most systems and deals only with static “input-output” relations between defined variables thought to be related. Neither restriction is satisfactory as a final target, but is often helpful in the initial stages of an investigation. It is, however, commonly recognized that static models are very inadequate and may be highly misleading in important respects; the reason lies in the fact that disturbances (and no system can be imagined to be in a completely steady state) take time to create their effect. So any “snap-shot” picture of a system at a given instant will reflect the influence of disturbances or other changes that occurred at some unspecifiable time earlier - and these disturbances may be unknown or unrecognized. In order to obtain a reasonably complete understanding of a system, its time-course behaviour - its dynamics - must therefore be taken into account. In practice, the dynamic performance of a system may be completely the major feature of its behaviour. Fortunately there are well-defined techniques for studying the dynamics of systems - complex systems; unfortunately these methods are themselves quite complicated and difficult to apply, especially in large-scale systems that involve human behaviour.

One of the basic insights, applicable to all kinds of system, that has been reached, is that the structure of interconnections within a system is all important to its behaviour. Accordingly, the identification of

#### 4.8.1 The application of systems theory

General systems theory has some helpful insights to offer. For instance, it recognizes that system boundaries are determined not only by objective reality but also by the questions that are to be asked about the system. It also recognizes that if the system has a significant degree of complexity, then full insight into the way the system behaves, and why, requires more than a single representation.

Both biological and social systems are “open”, self-regulating and adaptive. These systems behave

the pattern and nature of interconnections within a system is based on critical further analysis.

Descriptive models of a system can be computer-implemented and then subjected to test. Often the interest is in observing the consequences, and perhaps also the cost, of specific strategies of intervention designed to achieve some long-term shift in the system. For instance, in a socioeconomic system involving societal, employment and health sectors, it may be a planner’s intention to achieve some specific health-development target, for instance a shift in the mean level of a particular **health variable**; the target requires a strategy to obtain the resources needed - probably at the expense of other resource cost centres elsewhere in the system - and this strategy will have consequences and costs elsewhere in the entire structure. In this case the key question is: which strategy is optimum to achieve the target, in the light of the costs and consequences in other sectors? Naturally, advance information of this kind would be very useful to development planning of any kind, and health development planning in particular requires information about a number of interconnecting sectors that link with health; hence the health planner is unavoidably concerned with multisectoral systems and their behaviour: the form and nature of pathways and the dynamics of the intersectoral relations.

as if goal-seeking and work through a “hierarchy” of quasi-autonomous systems each of which has its own adaptive targets, the relative importance of which may alter continuously.

The general systems analysis approach also highlights several other features. For instance although systems analysis must begin with a drastically simplified version of the real system, the gap between reality and theory must always be remembered. It is a recognizable mistake to isolate

one facet of the total problem, or one sector amongst several that interact. Oversimplifying the problem, or incorrectly simplifying it, does more damage than merely “getting the numbers wrong” - the whole system description may be hopelessly unrealistic.

#### 4.8.2 Modelling Methodologies

One of the major difficulties in multisectoral modelling is known to be the quantification of variables. Few satisfactory social or health indicators have been developed, and most cultural variables have only been poorly defined. Since it is easier to count rather than to measure quality, quantity indicators are generally substituted for quality indicators, i.e., numbers of persons employed in the labour force rather than the quality of the labour force, numbers of physicians and hospital beds rather than the quality of care. The only solution here is informed judgement in the choice of indicators and the search for an acceptably wide range of coarsely- or finely-quantified data to represent the variable.

Naturally, effort in analysis is only justified when the available data are known to be of high quality. But this is not frequent in the socioeconomic domain; the data are almost invariably subject to unpredictable error for many reasons. So it is necessary instead to develop a technique that will recognize inconsistent data and attempt to correct it.

Relatively few models so far aim to describe the relationships between health-development and performance indicators in other socioeconomic sectors in a quantitative manner. Quoting from Attinger:

“Economists preferentially use **Econometric Models**, usually a combination of economic theory, mathematics and statistics, in an attempt to describe the progressive implementation and the operation of health programmes, to study the relationships

Specifically, in the analysis of complex systems, it is easy to neglect input and output components or systems parameters that turn out to be fundamentally important for the functioning of the system and for the understanding of its behaviour.

between health status, health programmes, and economic variables, and to develop measures for health status. Econometric models have the longest history of policy applications among socioeconomic relationships. They suffer from the same problems as most other models of societal sectors, namely the use of indicators that characterize quantities but neglect qualities.... In an economic system, any variation of one variable is transmitted to all other variables and the full economic impact can only be measured on the basis of a model that describes all these induced variations”.

“Models based on the Analysis of Cross-Sectional Data compare the relationship between social and health indicators across a number of countries or regions for specific years. The major problem with this method related to the difficulties associated with aggregating countries (or regions) into subgroups which constitute a homogeneous ensemble. This problem can be overcome if the membership in any subgroup is sufficiently large to permit a statistical analysis”. It can also be overcome in time-series data by pattern-analysis methods; these group the data from different countries according to similarities of time-series pattern in an objective way, thus identifying more-or-less homogeneous groups of countries or regions (Sayers, Attinger, Panerai), and allowing data aggregation to a potentially useful extent.

“If rate-of-change variables are included into the components of the input vector, the time course of health development in terms of the changes in the importance of individual determinants can be characterized.

Path-analytic techniques assume unidirectional cause-effect relationships and are therefore not suited for the analysis of systems with feedback loops, although there are methods that circumvent these problems. For example, analysing a model consecutively in a forward and a backward direction will, in general, result in different path coefficients. These differences can, with due caution, be interpreted in terms of feedback relationships”.

Models based on **Time Series Analysis** (initially developed by engineers for the analysis of man-made systems with time-varying inputs), are most easily carried through when a possible structure for forward and feedback pathways interactions and subsystems is known. If longitudinal records of sufficient length for all the variables involved are available, the quality and homogeneity of the data are easily assessed by enhancing and then quantifying the pattern features and describing their specific properties. The data series may represent variations with location, or with time, or both. Using mathematical transform methods and “white noise” analysis, these methods provide a description of the dynamic behaviour of the system under consideration that is limited only by the frequency at which individual variables are sampled, the number of samples and the degree of nonlinearity of the system.

In brief, “developing a successful model is based on two prerequisites that are difficult to quantify: **a priori** knowledge of the system, and intuition. An example of the former is the early attempt to demonstrate the economic impact of an improvement of health development where simple macroeconomic production functions were used without any consideration of the complex interdependence between population, labour force, capital requirements and output. The optimistic results published some 20 years ago have recently been greatly revised”. The need for intuition is illustrated by “pathanalysis models” describing infant mortality as a function of demographic, socio-economic and health resource variables, which gave

strikingly different results when the pathways were arranged quite differently according to their author’s intuition”.

“Even with **a priori** knowledge and intuition, the choice of the statistical methods used for the development of the model is crucial. The usual statistical methods (regression, analysis of variance, canonical analysis, discriminant analysis) are not well suited for the selection of a minimum set of variables to characterize the **structure** of a system; some structure is assumed”.

“In another group of statistical methods, the data are considered **a priori** structureless; the analysis is aimed at discovering a structure. These methods include principal component analysis, cluster analysis, and multidimensional scaling on the one hand, and time-series analysis on the other hand”.

But the quality of any research on health development based on a systems analysis approach rests first and foremost on the type and quality of the data collected and on the choice of indicators to describe the subsector. A number of questions, such as those that follow, must be considered before a set of data is subjected to formal analysis.

How did the data arise? From experimental design, as survey, or by chance observations? Is the definition of the variables consistent and unequivocal across the dataset and over time? In what manner have the data been aggregated?

Are the data representative of the system we are trying to model? Were the important variables selected? Is the range of responses to a change adequate? How reliable are data? Any missing data? Are the data available over a sufficient time-span to represent the dynamic behaviour of the system adequately?

In general it is found that there are few reliable data about many determinants that are clearly important to health, such as urbanization. Present data collection systems are clearly inadequate and

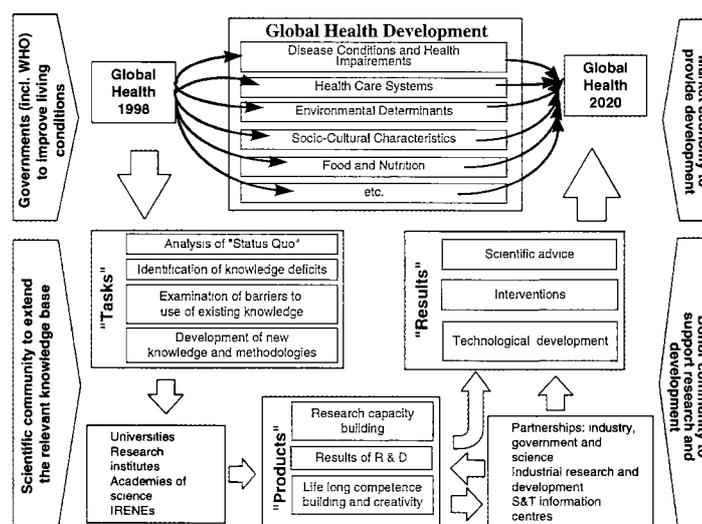
deficient; better (faster, cheaper, more accurate) collection and dissemination methodologies are needed. This is a major bottleneck to the use of systems analysis in this field, because the level of development of the systems **analytical** methodologies currently available is adequate, although still fraught with many problems. New technical developments are likely, in any case, to remove some of the restrictions which presently limit the applicability of multivariate statistical methods

to both cross-sectional and time domain analyses.

The major problem lies with the backbone of the research strategy, namely the availability of sufficient and reliable data for the characterization of determinants and their use as meaningful and consistent indicators of the performance of individual subsectors in health-related and health-development models.

## 4.9 Mobilizing the scientific community and partners

The Research Policy Agenda proposes to bring the above sciences, and indeed the entire scientific community and other relevant partners, together to address the main issues, assume priority “tasks”, and develop the needed “products”, leading to the best scientific advice, technological development and interventions - in short, the “results” need to ensure global health development. (This process is schematically represented in **Figure 5**).



**Figure 5: Responsibility of the scientific community and other partners**

The vision of the Research Agenda is to harness the power of the scientific community, on a time scale stretching between 1998 and say, 2020, to undertake research that will lead to products (insights, physical products and processes) for health protection and development, available for implementation by governments and the private sector.



# 5 Research imperatives and opportunities:

## Substantive domains

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- ◆ Health profile - Domains of global health
- ◆ Domain-oriented research
- ◆ Interdomain-oriented research
- ◆ Research imperatives addressing specific health problems

**“Carpe diem” - Seize the day of opportunity.** Entering the Twenty-first century, the challenge is to mobilize all possible research capabilities and sources of knowledge to address the full range of problems, opportunities and imperatives that pave the road to health for all. Priority must be given to greatest needs and priorities, as objectively measured, and as defined by individual countries and people themselves. Although it is entirely appropriate to mobilize efforts and resources for problems deemed of “greatest global burden”, this does not mean that science and public health should ignore local needs and conditions that rank lower on the global scale. Besides, basic research on

common underlying causes and determinants of a number of different health problems may have higher returns in the longer run. While there are worthwhile opportunities for targeted short-term outcomes, “products” and “best buys”, the path of science and public health generally require longer term vision and sustained effort on the part of all. Research efforts may be targeted for short-, medium- or long-term results. The longer term the research effort, the higher will normally be the ratio of basic to applied research. It is nearly impossible to identify a major research effort that does not require multidisciplinary involvement.

### 5.1 Health Profile - Domains of Global Health

The Research Policy Agenda proposes to bring all relevant scientific disciplines and efforts to bear on the main domains of human health, as reflected in the **Health Profile**. This is a new tool for visualising and helping to analyse the prevailing health conditions, health problems or deficits, as well as the imperatives or opportunities for critically-needed research that will contribute to problem solution. The Health Profile is a computer-based visual display that is designed to show the totality of the health status of a country, region or community, in a way that allows cross comparisons between different geographical areas, and health domains at different times (See Annex B, for a fuller description of the Health Profile).

The Health Profile provides a standardised means of weighting or ranking health-related problems or

deficits, as well as means of recording the estimated impact of alternative research initiatives or interventions. The Health Profile can thus be used as an aid to priority setting, policy making, operational thinking, resource allocation, programme development and evaluation. The Health Profile is presented in the form of a circle, which helps to visualise the cross-relationships between different factors or determinants that interact upon each other. The Health Profile can be sub-divided into as many measurables or components as desired. For purposes of the initial Planet HERES analysis, the Health Profile presents five major **domains of global health**:

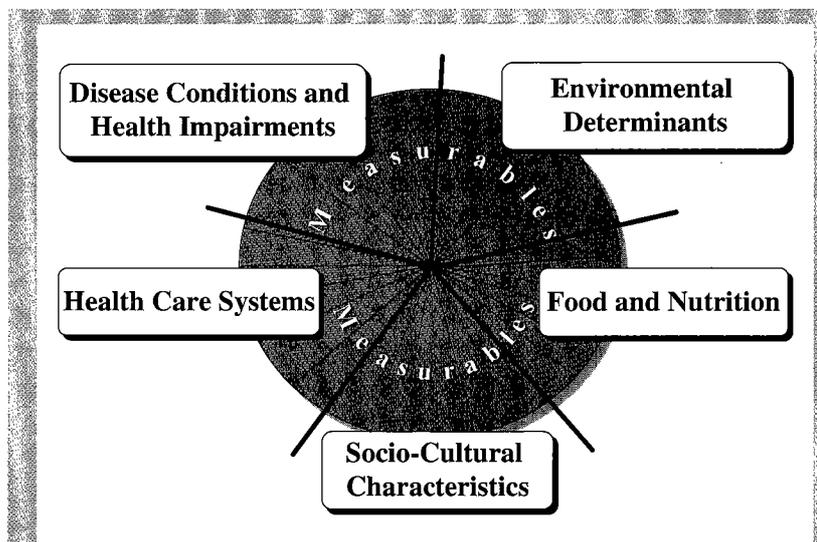
- Disease conditions and health impairments
- Health care systems

- Environmental determinants
- Food and nutrition
- Socio-cultural characteristics

The five health domains are shown in graphic form in **Figure 6**.

## 5.2 Domain-oriented Research

The Health Profile approach helps identify and give due emphasis to the magnitude of specific health problems within the five domains, whether at global, national, or regional level, and time-to-time comparisons will reveal trends towards aggravation or problem solution. For example, in a given tropical country malaria may show recrudescence, calling for immediate investigative research into why this is happening and what needs to be done about it. If this situation is repeated in many different countries, without adequate solution, dialogue among health planners and the bioscience community may call for global level priority to develop an effective vaccine. In another country, the health system's ability to provide adequate immunization coverage may appear satisfactory, as reflected by a marked reduction in vaccine preventable diseases of childhood, suggesting that holding current course is a good solution in that country. However, problems of dose-rate or vaccine stability may call for more basic research at the international level. In a



**Figure 6: Five health domains**

Decision-making in the health field should start from an objective, comprehensive and comprehensible description and analysis of the health "system" - for populations as well as individuals. The Visual Health Information Profile (VHIP) is an instrument that allows determinants of health development to be displayed in an innovative way in a "profile" of the health of a given population. The figure shows the five domains of health which are of interest to this initiative.

The VHIP instrument will function as the basic platform for the identification of gaps in knowledge - as one input to the research planning process - and for the application of other decision-support devices such as statistical packages, modelling and simulation tools. It uses a computer-implemented visual display drawing data as needed from a comprehensive underlying database.

particular community, there may be conditions of drought and an absolute shortage of water which can be investigated and resolved by the appropriate Ministry with or without further research, “within” the relevant domain. The same may be true within the domain of food and nutrition, or behaviour and health. The conventional view has been that most research needs can be assessed and resolved **within**

respective domains, drawing chiefly on one scientific discipline or one sectoral authority “responsible” for that domain. In practice, this conventional view is misleading, because health problems tend to have inter-domain causes and consequences, and major research needs can rarely be met by one discipline acting alone.

### 5.3 Interdomain-oriented Research

The circular design of the Health Profile helps suggest that health problems shown on one side of the Profile may, and probably do, interact with other problems on the other side, or in other domains of the Health Profile. If we take the well-known “intra-domain” problem of malaria cited in 5.2 above, for example, we see that the responsive research and intervention is almost certainly interdomain and interdisciplinary in nature. The recrudescence of malaria in the country may have little to do with the health service system as such, but everything to do with how waste-water is being handled in the environment and how populations are migrating, consuming natural resources and creating conditions for mosquito breeding and human contact. Water engineering sciences may be needed to control waste-water, clean up breeding areas, and design safe water supply systems. Agricultural science and sectoral authorities may have to deal with the links between agricultural practices, nutrition and mosquito vectors. Biodegradable larvicides or insecticides may be called for to control vectors in a way that will not create hazards to human health and environment. Parasite resistance to antimalarials may have to be assessed, and new combinations of prophylactic or therapeutic drugs may be called for. Perhaps well-designed, mosquito-proof, impregnated bed-nets will reduce the exposure rate. Sociological, behavioural, economic and demographic sciences may be needed to address the issues of population migration, employment, land use and hygienic practices. Finally, analysis may suggest that the ultimate solution would be

development of an effective vaccine. This could not possibly be accomplished within the capacity and resources of institutions in the country concerned. Only by uniting the international efforts of the scientific community at global level, will this ultimate solution be attained. This requires application of sophisticated microbiological, genetic and chemical engineering sciences working in concert, followed by product development, testing and international trials. Thus, while malaria may be “classified” as a “condition of disease”, the underlying determinants of disease and ill-health lie in the other four domains, and the solutions require multidisciplinary approaches extending far beyond the discipline of “medicine” *stricto sensu*. It is fully recognised that malaria is a classic example of multidiscipline, multi-domain research and operational intervention, but this characteristic is true of many if not most “health” development areas.

In outlining research imperatives and specific health problems below, it is not intended to provide either an exhaustive or prioritized list, but rather an indication of the scope and variety of some of the research needed in important health areas. Further dialogue will be needed with the scientific community and others concerned, by electronic means and in meetings and workshops, to identify the most critical issues, the best opportunities, and the means for technical collaboration and support. What, then, appear to be some of the main areas of research imperatives and opportunities?

## 5.4 Research imperatives addressing specific health problems

- ◆ Disease conditions and health impairments
- ◆ Health systems and policies
- ◆ Family, perinatal and reproductive health
- ◆ Environmental health
- ◆ Food and nutrition
- ◆ Mental health and healthy behaviour

**Research is essential.** The prerequisite for any degree of success in world health promotion and development must be basic and operational research that will increase our understanding of the epidemiology, causality and interrelationships among prevailing conditions of disease, ill health and poverty, and the means of overcoming them. The immediate priority for most developing countries, over the next two decades at least, will be for research that will promote and enable the fulfilment of well-known basic needs, namely the equitable provision of sufficient, healthy food, clean water, sanitary facilities, housing, prevailing disease control measures including immunization, availability of fertility regulation, basic health care systems and services, and at least basic education. Research continues to be needed on a range of specific communicable disease threats, with particular attention to tropical countries. Close on the heels of these efforts must be the promotion of

research on the “constitutional” diseases and conditions, including non-communicable, hereditary and “chronic” diseases, effects of environmental change and pollution, psychosocial and behavioural conditions, including addiction, violence, nutritional excess and other conditions of “affluent” society. There are opportunities for a fuller understanding of the interrelationships among economy, habitat, population dynamics, social policy measures, human health and quality of life. Every breakthrough in any one domain creates new challenges and opportunities in others. What is striking in the following discussion is the richness, complexity and interrelationships of the research that is required. Research needs are presented here in a fairly conventional manner as health programmes within health domains, although most of the research needed is in fact multidisciplinary and inter-domain in nature.

### 5.4.1 Disease Conditions and Health Impairments

**Main products of research.** Basic and applied research is imperative for the prevention and control of diseases associated with poverty, and for new and emerging diseases, both communicable and non-communicable, with special attention to the tropics, drawing on the full range of biomedical sciences as well as research and development of the health policy and systems type. Depending on the nature

of the priority disease or other health problem to be addressed, efforts and resources need to be mobilized and directed eventually to obtain at least five main categories of “product” for disease control:

1. **Surveillance.** Research into methodologies for local, national and international surveillance, and better epidemiological

understanding, of existing, new and re-emerging diseases and conditions of ill health, together with related continuous evolution of ongoing prevention and control strategies and technologies, and monitoring of microbial and other resistance to available drugs, vaccines and preventive or therapeutic means.

2. **Vaccines.** Research into and development of new, improved and more affordable vaccines for infectious or communicable diseases caused by defined, alien pathogens, and preventable by immunization, and seizing new opportunities for prevention and treatment of certain “constitutional” non-communicable diseases amenable to immunological and gene-based solutions.
3. **Drugs.** Research into and development of new, improved and more affordable antibiotics, chemotherapeutic agents and other pharmaceutical preparations, including those from medicinal plants, to keep ahead in the evolving “race against the bugs” and provide affordable, effective means of health protection and care at all appropriate levels of the health system, and suitable to local needs and conditions.
4. **Diagnostic tools.** Research into simple, rapid diagnostic tests and related technologies for the detection, analysis and typing of bacterial, viral, parasitic, zoonotic and other infectious disease agents, and for the prediction of susceptibility or predisposition to, and measurement of onset and staging, treatment and outcome of communicable and non-communicable diseases conditions.
5. **Control strategies.** Predominantly operational research into appropriate, efficient, effective, affordable and socially acceptable strategies, systems, services, methodologies and technologies, as well as basic and necessary advanced education and

training for the prevention and control of communicable and non-communicable diseases and conditions, together with related theoretical and applied research on inter-related environmental, demographic, social and economic factors which impinge on health conditions and outcomes.

**Communicable/infectious diseases** still constitute the predominant cause of death throughout most countries of the world. They know few boundaries between countries, population groups or individuals, and they in turn represent both contributing cause and effect of poverty, malnutrition, defective hygiene and genetic condition. In the “race against the bugs”, research continues to be needed on **acute respiratory infections**, especially pneumonia, which contribute to fully one-thirds of deaths in children under five in developing countries. Almost half of pneumonia deaths are caused by the single organism, *Streptococcus pneumoniae*, and the spread of drug-resistant strains worldwide is a cause of serious concern and research attention. *Pneumococci* and *Haemophilus influenzae* are among the most common agents of acute respiratory infections in children, and are becoming increasingly resistant to available drugs. Research is needed to better understand such antimicrobial resistance, to identify ways to reduce the inappropriate use of drugs, and to develop and evaluate new and combined drug therapies and improve case management, including home care. Return of the 1918 type of influenza, being a current nightmare for public health science, it is important to maintain existing surveillance of emerging strains, and find ways of strengthening this, and adapting vaccines and control measures accordingly.

More research attention must be given to tuberculosis which, among infectious diseases, is the single biggest killer of adults and responsible for more than a quarter of avoidable adult deaths worldwide. The emergence and spread of multidrug-resistant strains of the mycobacterium is a major obstacle to tuberculosis control. Further research is

needed to improve our epidemiological understanding of the prevalence of drug-resistant strains and to design countervailing strategies to extend coverage of “directly observed treatment, short course” (DOTS). Research avenues include detailed sequencing of the genome of the causative agent, and development of immunogens, a vaccine and/or means of mass chemoprophylaxis using a single dose, long-acting injectable agent. Basic research is needed on the interactions between tuberculosis and other disease conditions, including HIV/AIDS.

Among **vaccine preventable diseases of childhood**, measles is still the leading killer, but is coming under control by immunization campaigns, together with diphtheria, pertussis, poliomyelitis and neonatal tetanus. Research is needed to further ensure vaccine effectiveness and cost reduction, and to develop heat-stable, single-dose vaccines that can be given in oral or aerosol form. New delivery products could include slow-release microencapsulated vaccines and vaccines based on new DNA and gene technology. Although an effective vaccine is now available for hepatitis B, research is needed for other strains, especially hepatitis C. Drug-resistant Meningitis is an emerging problem, and research on better drugs and vaccines is needed.

**Diarrhoeal diseases** account for one quarter of all child deaths in developing countries. While oral rehydration therapy is effective against most acute watery diarrhoeas and must be widely promoted, research is needed to counter drug resistance in pathogenic *E. Coli*, giardiasis, salmonella including typhoid, bacillary shigella and other forms of dysentery and cholera, and to develop effective vaccines against these diseases, including rotavirus. There is insufficient knowledge about the biology and history of giardia, for example, and some of these pathogens, such as new strains of cholera, have shown inexplicable resistance to almost all known antibiotics. Thus further basic research is needed. Local operational research is necessary to optimize application of available technology and extend coverage at acceptable cost.

**Sexually transmitted diseases and AIDS**, including gonorrhoea, syphilis and chlamydial infections, require increased attention from the research community. Research is needed on ways of reducing transmission, and development of simple, affordable diagnostic tools and more effective biocides and means of therapy. The AIDS pandemic is being fought by a combination of health education and technologies to break transmission. Health promotion materials designed for “North Western” cultures may not be directly usable in other cultural settings, and must be re-adapted to local conditions. Today, there exist in developed countries, but only when available, very high cost multi drug therapy and means of palliative care. To win the battle, however, more basic research is needed to sequence the HIV genome and widen virological studies of variability and pathogenesis, with a view to developing a safe, effective and affordable HIV vaccine.

**Tropical diseases**, including **parasitic diseases**, continue to require special attention as they are caused by special conditions of the tropics combined with deadly or debilitating pathogens, for which the means and resources for prevention and treatment are still inadequate. Malaria, in spite of control successes in many countries, is still the leading contributor to mortality and suffering from tropical diseases worldwide, with about 40% of the world’s population at risk. There has never been, and we still do not have, any single “silver bullet” for malaria, although in the 1950s-1960s DDT held short-lived promise for vector control which proved unsustainable. Today, combination control strategies include epidemiological surveillance, multiple vector control methods, health education, prompt diagnosis, and drug prophylaxis and treatment. However, evolving parasite and mosquito vector resistance are an ever-present threat to control programmes. It is paramount ultimately to develop and apply a fully effective malaria vaccine. Existing candidate vaccines are only partially effective. Sequencing of the *P. falciparum* genome offers new opportunities for developing more effective drugs

and vaccines. Genetic engineering to make the *Anopheles* mosquito vector refractory to the parasite is a possibility. Local operational research is needed to optimize control strategies and apply appropriate combinations of effective technologies, including, for example, the use of impregnated bednets in affected communities. Basic research is needed to understand interactions between malaria and other diseases and conditions, and the human host.

Other tropical and parasitic disease deserve attention because, even when they do not kill, they still have devastating adverse effects on human health and socioeconomic development in countries that can afford it least. A continuing challenge to WHO's Special Programme for Research in Tropical Diseases (TDR) is how to maintain research attention and focus on tropical diseases, even when market forces alone might not suffice. Schistosomiasis (Bilharziasis) is still a debilitating disease in many tropical countries, and continued operational research is needed to improve snail vector control, protect water supplies, and apply effective available combined drug therapy. Filariasis diseases caused by microfilarial worms are scattered throughout tropical countries, requiring local operational research for improved vector control and application of available drugs and technologies such as DEC-medicated salt. Dracunculiasis (guinea-worm disease) is ripe for eradication if simple technologies are devised and used to ensure that water is carefully protected to break transmission. Many of these successful experiences and technologies, such as satellite and computer-assisted terrain mapping, can be applied to the control of other tropical diseases. Research in one domain will have payoffs in others. Basic research is needed on the combined effects of multiple and repeated exposures to infection by tropical diseases.

Onchocerciasis (river blindness) lends itself to blackfly vector larvicide control and prevention and treatment, particularly by Ivermectin, but local operational research is needed to enhance these control measures in affected communities. Research

is needed for safer, lower cost diagnostic tests and more effective drugs for African trypanosomiasis (Sleeping sickness) and operational research for optimal local application of tsetse fly vector control. Chagas disease is nearing elimination in the Americas, and local operational research will improve triatomid vector control, secure household dwellings, screening against the disease and patient management. Control methods for sandfly vectors of leishmaniasis are available, but they require local operational research for systematic application in affected communities. The age-old scourge of leprosy stands at the threshold of global elimination. Multidrug combinations offer real hope for success, provided application programmes and proper case management are pursued vigorously to avoid over- or misuse of antibiotics and other prophylactic and therapeutic drugs. The emphasis will then shift to rehabilitation of victims, surveillance against recrudescence, and use of successful experiences and know how in the control of other tropical and parasitic diseases.

Because of the **risk of re-emergence or outbreak of deadly diseases** from nature to human populations, and within and between countries, research is needed into how best to strengthen local, national and international surveillance of a panoply of potential disease threats, many of them originating in tropical countries and/or in wild or domesticated animals. Examples include the haemorrhagic fevers, such as yellow fever, dengue, Lassa fever, Marburg disease and Ebola. The fact that none of these diseases have reached epidemic proportions and crossed international borders in the last fifty years is a tribute to the World Health Organization and to local, national and international collaboration to detect and contain sporadic outbreaks. But there can be no room for complacency, and research is needed on how to optimize surveillance systems and methodologies. Other diseases of concern include typhus, spotted fever, plague, lyme disease and other zoonoses such as rabies, brucellosis, anthrax, and equine encephalitis. Each of these offers opportunities for research and development of more

effective drugs, vaccines, diagnostic tests and control strategies. The fact that any one of these diseases may not in itself score high on a list of “global burden” does not mean that the threat of resurgence is not present or that the intensity of individual suffering does not merit attention from the scientific research and public health communities. Rabies is a case in point. Research for an oral rabies vaccine for this agonizing disease was brought to a virtual standstill by budget downsizing of “lesser priorities” in the 1980s, until WHO and a small number of researchers and institutions persevered to develop what today is a safe, effective and affordable oral vaccine for wildlife rabies control and population protection in affected countries worldwide. What is needed now is surveillance, further regional or locally-specific research on operational delivery, and the political will to eliminate rabies as a disease of public health importance anywhere in the world.

**Noncommunicable diseases**, that is, the “constitutional”, “chronic” and/or hereditary diseases and conditions, represent the other great challenge for biomedical and operational research leading to disease control and human health. The fact that many of these are “diseases of development” or of “affluence” suggests that research attention and resources in industrialized countries will continue to be devoted to them, more reliably than to some of the tropical diseases and other conditions of poverty. Nevertheless, non-communicable diseases are of unquestioned importance and priority for health in the Twenty-first century. Their presence and rate of increase in developing countries is well-recognized as the “double burden” shared by both worlds. Also, the potential for dealing with these diseases is, and should be, increasingly shared by developed and developing countries. Some of the basic knowledge, technologies and methodologies arising from research and public health efforts to control communicable diseases, outlined above, may have indirect or even quite direct application to control of noncommunicable diseases, and vice versa. Basic

research on host mechanisms is vital to both, and community-based control strategies may have pay-offs in multiple domains of disease control and health promotion.

**Cancer**, which is the second most common cause of death in many parts of the world, is increasingly understood as fundamentally a disease of genes and internal cellular processes, which means that winning the war on cancer ultimately depends on basic research in molecular and cell biology and in genetic science. Nevertheless, the triggering events leading to the formation of neoplasms are predominantly external, notably: (a) exposure to carcinogens in food and the environment; (b) unhealthy lifestyles and risk-taking behaviour (e.g. tobacco smoking); and (c) infection by microbial and other disease agents. Consequently, many cancers are in large measure potentially preventable by practical control of external factors, and therefore research on these factors continues to offer promise of immediate pay-offs in cancer prevention.

The link between infectious diseases and cancers is becoming increasingly clear, suggesting that the success of scientific research and interventions against certain viruses, bacteria and parasites, will also constitute victories in the war on cancer. A substantial proportion of stomach cancer, for example, is attributable to the bacterium *Helicobacter pylori*. High proportions of cervical cancer are associated with papilloma viruses and other preventable or avoidable sexually transmitted disease agents. The greater share of liver cancers are traceable to Hepatitis B or C virus infection, so that immunization against these agents is also effective against liver cancer. Burkitt’s lymphoma is strongly linked with the Epstein-Barr virus, which is also often implicated in Hodgkin’s disease. In tropical countries, bladder cancer is a common consequence of schistosomiasis. Kaposi’s sarcoma is one of the salient manifestations of HIV infection in AIDS, which is often associated with other cancers, including non-Hodgkin’s lymphoma. The interrelation between infectious disease agents and

cancer represents a vast field of challenge for basic biomedical, epidemiological and clinical research, with great potential for cancer prevention as a byproduct of controlling these infectious agents.

The link between diet, alcohol, and tobacco and a wide range of cancers are well-recognized, although the underlying principles of oncogenesis are poorly understood. Excess fats in the diet, obesity, over-consumption of certain preserved, cured and salted foods, under-consumption of vitamins from fresh fruits and vegetables, and exposure to contaminants such as aflatoxins, as well as immoderate use of alcohol, tobacco products and certain drugs and food additives - all are risk factors for cancers of the stomach, colorectal system, bladder, liver, esophagus, larynx, oral cavity, lung and other organs. Tobacco smoking, including "passive" smoking, is by far the most important risk factor for lung cancer. Other factors include: occupational exposure to asbestos, certain metals (e.g. nickel, arsenic, and cadmium), radon and ionizing radiation, which in turn are risk factors for myeloma, malignant melanoma and leukemia. Continued epidemiological studies are needed as well as operational research on effective means of control of risk factors. At the same time, basic research is needed to understand the mechanisms by which these factors trigger cancer at the molecular and cell levels of the host. Hormonal imbalances are implicated in cancers of the breast, uterus, and prostate, but these processes are not well understood. The increase in testicular cancer in affluent societies remains a mystery, and there is some indication that estrogens in the environment could be a contributing factor. Research is needed to understand these mechanisms and apply practical control measures - in short, to ensure a balance between basic and applied research.

Cancer treatments continue to be developed, and there are opportunities for improvement and refinement of techniques in early diagnosis, surgery, radiotherapy, chemotherapy, phototherapy, hormone therapy, and combinations of these approaches, as

well as palliative care aimed at relieving pain and improving quality of life without inducing treatment-related toxicity or complications. For example, laser phototherapy is being demonstrated to be increasingly effective for the treatment of certain malignancies, being simple and minimally invasive, with a potentially high tumor cure rate and reduced morbidity. Most laser treatment performed on superficial malignancies can be done as an outpatient procedure reducing both the cost of hospitalization and anesthesia complications. Promising research is being carried out on the use of interstitial laser phototherapy guided by magnetic resonance imaging for the adjunctive treatment of deep and surgically inaccessible tumors of the head and neck. Photodynamic therapy is a new endoscopic procedure for the treatment of malignant or premalignant structure lesions, making use of the fact that photosensitizing substances can accumulate in tumor tissue and be activated by exposure to light of a certain wavelength, and by phototoxic reaction, can contribute to destruction of the tumor. Applications include elimination of cancers of the esophagus, stomach, colon and rectum, and removal of malignant airway obstruction of the lung. Fundamental work needs to be followed by wider clinical trials.

The greatest opportunities for cancer therapy may lie in the application of results of the current revolution in molecular biology and genetic science, including mapping of the human genome (see Chapter 4.1 above). The discoveries of the last two decades provide a striking new range of targets for the development of diagnostic tools and novel and more specific drugs for the treatment of cancers. Research is being undertaken to develop bio-indicators to detect prepathological changes, provide early detection, and monitor reversibility or irreversibility. Monoclonal antibodies will soon be available for immunotherapy of metastatic breast cancer, non-Hodgkin's lymphoma and other cancers. Their effectiveness must be carefully evaluated. Therapeutic vaccines are under development for melanoma and other cancers. "Anti-sense" drugs

show promise for “switching off” oncogenes in a wide variety of tumors. Gene therapy offers an ultimate solution to the treatment of many cancers, using different forms of viral or non-viral carriers, and even “naked” DNA to replace the functions of defective or damaged genes, such as p53, p16 and K-RAS. These therapies need to be tested under clinical conditions. Clinical trials are also needed, for example, to test the effectiveness in humans of the proteins “angiostatin” and “endostatin” to cut off blood supply to many different kinds of cancer tumours, in a non-toxic manner, without drug resistance or reversion to cancerous state. It is important that excellence in basic cancer research be maintained while at the same time every possible step be urgently taken to ensure the evaluation and rapid commercialization of these new therapies. Clinical trials must be put on the “fast track” for regulatory approval, leading to widespread clinical use. Only when large numbers of persons participate in such trials will the full effectiveness and benefit of these new technologies be realized. The challenge, therefore, is not only to maintain excellence in cancer research, but also to ensure a balance between basic and applied research, and ensure that the fruits of such research are brought rapidly to bear on human health.

**Cardiovascular diseases** together with cerebrovascular diseases constitute for most people the biggest risk to life. Coronary heart disease accounts for one-third of all deaths in industrialized countries, and rates are rising in developing countries. Among circulatory diseases, stroke and other cerebrovascular diseases are the second most common cause of death. High blood pressure or hypertension is the most common cardiovascular disorder and leading risk factor for other forms of disease, in developed countries, and it is taking on epidemic proportions in emerging middle class populations of developing countries. Major risk factors include overweight, poor dietary habits such as excessive intake of fats, salt, alcohol and tobacco, and inadequate physical activity. Research on community approaches to prevention of

hypertension and stroke has paid off, and renewed attention must be paid to health promotion and health education, drawing on experiences in different countries, cities, communities and cultures.

Basic research is needed, drawing on molecular genetics, to improve understanding of complex disorders such as atherosclerosis and essential hypertension, and leading to new diagnostic technologies for measuring predisposition to disease, early diagnosis, prognosis and treatment. It is necessary to continue to develop and improve a range of drugs for effective treatment of such conditions as hypertension, hypercholesterolaemia, cardiac arrhythmias, myocardial infarction and chronic angina. For example, thrombin inactivators and fibrinogen receptor antagonists offer promise of improvement of the efficacy and safety of antithrombotic therapy. The search must be continued for chemopreventive agents, such as the use of nonsteroidal anti-inflammatory drugs, tamoxifen-like anti-estrogens and calcium-fibre preparations. Basic research must continue to be directed toward the development of gene therapies to reduce predisposition and clinically treat a number of cardiovascular and cerebrovascular disorders. Meanwhile, improvements in surgical, clinical and rehabilitative methodologies should continue to be sought, including bypass technologies, angioplasty, microsurgery, valve replacement, heart pacers, human organ and xenotransplantation and repair, artificial materials, immunosuppressors, imaging technology, rehabilitation techniques, case management, patient education and palliative care. Research is needed on how to establish effective, efficient and affordable systems for organ donation and transplant, with due attention to fundamental issues of equity, ethics and cost.

**Other chronic diseases** deserve research attention, particularly diabetes which is increasing in all countries as a reflection of aging population, unhealthy diets, obesity and sedentary lifestyle. Undernutrition can be a factor in some tropical countries. Control of risk factors is a major strategy for

prevention of disease. Diabetes mellitus is a hereditary disease which offers the opportunity for molecular therapy and eventual possible genetic correction of the germ line for future generations. Short term gains can be made by improving health services and the availability of lower cost essential medicines, such as insulin, blood glucose monitoring and patient education, as well as new surgical and clinical methodologies, such as pancreatic tissue transplantation. Gene therapy is particularly promising for a number of **hereditary diseases and birth defects**, including haemoglobin disorders, such as sickle cell disease and thalassaemia, as well as cystic fibrosis, muscular dystrophy, haemophilia, Down syndrome, and other congenital malformations. New drugs, surgical procedures, replacement materials and prosthetic devices are needed for musculoskeletal disorders, such as osteoarthritis, rheumatoid arthritis, osteoporosis and low back pain. In osteoporosis, the experience of hormone replacement therapy has been encouraging. So too have the first results of studies on the use of antiresorptive agents such as a nasal spray form of calcitonin. Transforming growth factor B and insulin-like growth factor are promising candidate for increasing bone formation in older people. With new agents such as cytokine inhibitors, improvements are also indicated in the treatment of arthritis, such as in the use of genetically-engineered human interleukin-1 receptor antagonist to relieve rheumatoid arthritis, reducing inflammation and joint tissue destruction. Basic research can lead to highly effective, practical and eventually affordable treatments for many of the chronic or “constitutional” conditions.

**Other health impairments** and conditions deserving research attention include blindness, hearing impairment, accidents, burns and injuries, and oral health problems. About 80% of **blindness** is avoidable, that is, treatable or potentially preventable. Xerophthalmia, or childhood blindness, is a vitamin A deficiency disease that can be controlled by vitamin A supplementation in affected

communities or individuals, but the challenge to local operational research and social innovation is then to ensure availability of a healthy green leafy vegetable diet so that supplementation will no longer be necessary. Trachoma, a chlamydial infection, can be controlled by antibiotic eye ointment, but the challenge is to promote the basic hygiene and fly control that will eliminate the problem. Onchocerciasis is coming under control by a combination of blackfly vector control and effective drugs, notably Ivermectin. Cataract is the result of ultraviolet radiation, exposure to dust particles and effects of aging. Eye protection helps provide primary prevention, but continued scientific progress is needed in surgical techniques, and affordable intraocular lens implantation and lens manufacturing capabilities. Improved drugs, surgical techniques and laser treatments are needed for control of glaucoma and retinal impairments. New electronic equipment is becoming available to facilitate reading and other intellectual activities of blind persons. In the next century there are long term possibilities of restoring eyesight at least in surrogate form for completely blind persons. Deafness and other **hearing impairments** are due to infections, trauma, misuse of drugs and aging. Extraordinary advances have been made in developing sign language for the deaf. There are opportunities for better drugs, case management, affordable hearing aids, and eventually surrogate systems for restoring hearing to totally deaf persons.

**Oral health** conditions, which are evolving rapidly in response to socioeconomic change, are an area requiring continued epidemiological research, and adaptation of prevention strategies, such as appropriate use of fluorides, better dental instruments and techniques, such as atraumatic restorative treatment, to combat dental caries, periodontal disease and malformations. Research is needed on the epidemiology and prevention of the disfiguring oral cavity disease Noma. A challenge for operational research is how best to integrate oral health into the overall health care system.

**Disabilities and impairments** due to diseases and constitutional conditions, natural and man made disasters, war, violence, traffic accidents, accidents in the home, especially burn injuries, occupational hazards in agriculture and industry, and excessive risk-taking behaviour, appear to be on the rise in virtually all countries. There is fertile ground for research into risk factors, means of prevention, mitigation of consequences, emergency preparedness, emergency response, treatment and care, physical and psychological rehabilitation, safety devices, prostheses, and health promotion and education of the public. **Accidents and burns** can be reduced by safety warnings, better vehicle and housing construction, safer quality of appliances, increased use of smoke and fire detectors, the use of flame retardant sleepwear for children, and effective prevention programmes. Research is needed for new and improved technologies in surgery and management of burn patients including techniques for tissue expansion and transfer, culture derived and synthetic tissues, and improved topical antimicrobial therapy. Prevention should focus on the common causes of burn injury and the most effective means of reducing its consequences. Research should place emphasis on identifying pharmacological agents to reduce and reverse oedema formation, on developing improved means of mechanical ventilation to reduce barotrauma, and on elaborating techniques to quantify the severity of inhalation injury. Other important research areas include improved topical chemotherapeutic agents, non-antigenic culture-derived composite tissue, nutritional support regimens and growth factor therapy to enhance wound healing. There are new opportunities for making "high tech" human body repairs accessible to more and more persons. Using the body's own stem cells, scientists are developing intricate techniques to regrow blood, tissue, tendons and cartilage, and restore bone loss - breakthroughs that will benefit accident victims, disabled persons, cancer patients and injured athletes. Remarkable advances are being made in the development of equipment designed to enable disabled persons to

live more normal lives, including transportation systems, wheel chairs, electronic equipment, robots and prosthetic devices. Further work is needed to revise and update the International Classification of Impairments, Disabilities and Handicaps.

**Diagnostic, therapeutic and rehabilitative technology** is needed to support programmes dealing with the entire range of communicable and "constitutional" diseases and impairments. Improved and simplified surgical and anaesthetic services and procedures are essential to support district and peripheral health care services. Research is needed on methodologies for quality assurance, standardization, and production of basic laboratory reagents and blood safety. New ways of protecting blood products and tissues, including development of artificial substitute or replacement products, are desirable. Quality assessment is needed to improve the performance of services dealing with clinical chemistry, haematology, coagulation microbiology, and parasitology. Advanced technologies are being used to develop new drugs and vaccines, for example those synthesized by recombinant DNA technology and use of monoclonal antibodies. Harmonization of approaches to drug registration and standards for good laboratory practice in the field of pharmaceutical development are necessary components of drug management policies. The WHO Model List of Essential Drugs will continue to need adaptation and updating. Guidelines need to be developed and adapted for standardization, assessment of efficacy, and utilization of traditional medicines, including herbal preparations. All of these technologies and approaches will in turn benefit from new developments in communications, informatics, electronics and robotics. Laser capture microdissection, for example, is a new technology that will facilitate research at the molecular, genetic and cell levels. In the field of radiation medicine, research should continue to explore ways of improving imaging technology, including basic radiography, computed tomography, magnetic resonance imaging, sonography, digital subtraction

angiography, radioisotope imaging, as well as photon and positron emission tomography. Thus the sciences of engineering and electronics must link up with the biomedical and social sciences to

develop and deliver the knowledge bases and technologies needed to diagnose and treat disease conditions and deal with health impairments in the next century.

#### 5.4.2 Health Systems and Policies

**Primary health care** has been for the last twenty years the main global priority for research and development in health care systems, especially in less developed countries. The main objective, which continues to be valid today, has been to ensure that essential health needs and local priorities are met, by appropriate, effective and affordable technologies and services that are universally accessible, covering prevailing health problems, and including health education, nutrition, safe water and sanitation, maternal and child health care, family planning, immunization, locally endemic disease control, treatment of common diseases and injuries, and provision of essential drugs. The absence of or inequitable access to these kinds of basic services is a hallmark of the concept of poverty, viewed in terms of both cause and effect. The primary health care concept is independent of political system or ideology, but it emphasizes a blend of individual, community, intersectoral, governmental and non-governmental responsibility and participation. The research counterpart of primary health care is “essential national health research” a concept first discussed by ACHR in 1978, to address the main health problems within the country and communities concerned, and propose solutions for prevention and control, cost-effective systems and services organization and delivery, allocation of human, technical and financial resources, financing and administration, as well as monitoring and evaluation. Much of the technical advisory support to countries by WHO, COHRED and other international institutions has been, and continues rightly to be, focused on overall health policy and priority setting, and local, operational, context-specific research on planning and management of disease prevention and

control programmes and services delivery, including the design of essential health care packages for home care and the peripheral level of the health system. A continuing challenge for research is how to integrate the different health promotion, prevention and treatment service components of the health care system, and determine the appropriate supervision, referral and support between different levels.

**Equitable coverage** for all population groups and geographical areas throughout the country is a major ethical and practical issue for most developing countries, and indeed for many developed ones, given widely different living conditions and disparities in available resources. Much of the early experimentation in primary health has been aimed at rural health, given the remoteness of rural populations, their lack of disposable income, and the difficulty of access to health services. In view of the current trends in population dynamics and urbanization (as further discussed under Section 5.4.4 below), more research must be focused on urban health, dealing with problems of poverty, overcrowding, pollution, anti-social behaviour and lack of community organization. There is also an emerging awareness of the challenge of health in border areas of adjacent countries, which frequently exhibit problems of remoteness, lawlessness, social conflict, refugees, trans-border transmission of disease (e.g. malaria) and lack of services. Many countries, even highly developed ones, have their pockets of poverty or “zones d’ombre” which have significantly inferior conditions of health and welfare than the actual national averages. Local, national and international comparative research is needed to understand the nature, causes of and

means of overcoming these disparities.

**Health manpower and human resources research** is an important aspect of health systems research. The needs is not only to identify the types, quantities and qualities of needed manpower, in the “conventional” sense, and thus the education and training curriculae and facilities required, but also to develop the means of bringing “unconventional” forces, including family members, citizens’ associations and other non-professionals into the health promotion, protection and care arena. What, for example, are the potentialities, risks, responsibilities, limits and optimal means of fostering different forms of individual “self-care”? Much debate has already gone into questions of equivalence and standardization of professional degrees in different countries, with due attention to the adverse effect of “brain drain”. But perhaps not enough has gone into the basic question of how well the curriculum addresses current, emerging and “transdisciplinary” issues that will be met in practice. Nursing research issues of importance include: health care reform, supply and demand, working conditions, education and training, quality of care, ethical aspects, home care, occupational health and role in disease prevention and control programmes. “Telehealth”, “telemedicine” or “telematics for health”, that is, the use of telecommunications and informatics for health promotion and protection is a growing area for research and application within and between countries.

**Health policy and systems development research** for the future must adapt and respond to a rapidly changing world, characterized in many countries by: socioeconomic and political change, tensions and contrasts; decreasing per-capita resources and increasing demands; increased role of market economy and change in perceived role of government at different levels; continued industrial and technological progress; emerging democracies and endless war and civil conflict; the persistence of poverty and the growing disparities between

nations, population groups, rich and poor. “Upstream” policy issues requiring national and international comparative research include: priority setting, health needs assessment, resources rationing and allocation, financing mechanisms, public and private sector roles in health care, regulatory and incentives issues, reform and decentralization, quality assurance and monitoring systems, as well as policy process and policy analysis. Further areas for health systems related research include: the adaptation of human resources policy, education systems, training curricula and employment structures in health and public sector reform; how to promote greater dialogue with what is becoming known as “civil society” and communities; and the influence of other sectors (industry, agriculture, education, etc.) on health outcomes and on the role of the health sector. New approaches to dialogue and learning include continuing education programmes and education “at a distance”, using media and telematics, and application of new information and communication technologies.

**International comparative research** is needed on how health systems are organized, and on the impact of differences in health care expenditure among countries on utilization, access and health outcomes. The right balance must be found in the priority setting process between the priorities as perceived by people and communities themselves, and priorities indicated by objective, scientific evidence. Can the two be brought closer together through information, communication, education, promotion and process reform? National and international comparisons are needed on financing mechanisms, including experiences with user charges, pre-payment systems, health insurance and community financing, with attention to issues equity, quality, affordability, and responsiveness to demand, as well as incentives on the demand and supply sides. What are the implications of different fee levels? Issues of equity and the effectiveness of exemption mechanisms require further study. Research is needed to help policy makers and planners in countries to review ways of harnessing the private

sector to achieve national health policy goals. Regulation and incentive setting, integrating private practitioners into the health care system, and evaluating alternative modes of private practice by public doctors, emerge as research priorities. The question of decentralization and definition of appropriate levels for responsibilities and services continues to be an area of research priority, including assessment of the new-type managed market model. To facilitate these comparative studies, further research is needed to develop and refine “outcome” indicators for demographic and epidemiological trends, and “input” and “process” indicators, including descriptors of processes and policies.

**Quality assurance and monitoring systems** are important areas for research. Intervention studies are needed comparing alternative quality assurance approaches, including for example, competency-based training, job aids, patient counselling and communication of standards. The recent developments in communications, computer technology, software, knowledge-based systems, geographical information systems, and analytical tools offer promise for better understanding, analysis, control, monitoring and evaluation of policy-setting and decision-making processes,

system design and institutional organization, and delivery of health programmes and services, thus ensuring better performance, accountability and consumer choice. A better understanding of the policy process and environment of the health system will have valuable pay-offs in all other health development domains.

**Economic and other intersectoral policies** and practices have an overriding impact on health outcomes and quality of life. Research is needed to understand the nature, causes and outcomes of poverty, which is itself a composite of deficiencies in access to material, financial and service resources. Comparative research is needed on the impact and interrelationships of macro-economic policies, trade agreements, industrial and agricultural policies, incentives, taxation, employment, pensions, social security, health insurance, education, consumption behaviour and regulation of public hygiene, as well as social policies concerning women, children, the elderly, vulnerable groups, race, religion and political belief. Further aspects of policy research are outlined below in the contexts of family and reproductive health, the environment, food and nutrition and human behaviour.

### 5.4.3 Family, Perinatal and Reproductive Health

**Maternal and child health** continues to be an area of unmet needs requiring basic and applied research to understand underlying conditions of health and ill-health, and to develop and adapt technology and approaches aimed at protecting and promoting the health of women and children, and the strengthening of the role of all members of the family in health care, child rearing and preparation for parenthood and other stages of life. The importance of giving research and operational attention to neglected aspects of maternal health and newborn care, and the essential link between the health of women and children and family planning were reflected in the Convention on the Rights of

the Child, and in the Declaration and Plan of Action of the World Summit for Children. Safe motherhood is a key issue. Maternal mortality is one of the most sensitive indicators of the status of women and women’s health, and of all health indicators, shows the greatest differentials between developed and developing countries, and between population groups within countries. Epidemiological, behavioural and operational research continues to be needed to understand the magnitude of maternal mortality and morbidity, its causes and contributing factors related to social and health systems. Maternal complications to be addressed include haemorrhage, sepsis, hypertensive disorders of pregnancy,

eclampsia and pre-term and obstructed labour. Excess fertility and malnutrition are compounding factors adversely affecting mother and child.

**Perinatal health** is a major objective of global health development, critical to the health of mother and child, and a major determinant of the subsequent health and development of the young child growing into adulthood. Infant mortality rates are still as high as 200 per 1000 live births in some least-developed countries, and intense efforts must be made to transfer and apply simplified but effective technologies in all countries, to meet the WHO target of an infant mortality rate that will not exceed 50 per 1 000 live births in any country or significant population group. Prenatal conditions requiring research attention include birth asphyxia, hypothermia, birth injuries, sepsis, prematurity, malnutrition and low birth weight. Perinatal complications can include a number of communicable diseases infections acquired during pregnancy or delivery, including sexually transmitted diseases, neonatal tetanus and hepatitis. Operational research in perinatal care is needed to further develop, adapt and apply the “Mother-Baby package” of services for antenatal care, clean delivery practice and neonatal care in the first week of life. The WHO/UNICEF “baby friendly hospital” initiative is designed to encourage healthy newborn care and breast-feeding.

**Child health and development** is a major area for behavioural and operational research. More than a quarter of the global disease burden is caused by conditions that primarily affect children, especially in low-income populations. Four diseases contribute to the majority of childhood deaths: acute respiratory infections, diarrhoea, malaria and measles. When malnutrition is added, these conditions account for over 70% of all child deaths. In view of the interrelation between malnutrition and disease, strategic research is desirable to understand the relative importance in different environments of increased intake of appropriate nutrients, and control of infectious disease, as means of reducing

malnutrition and promoting child health. Research is needed to refine, implement and evaluate in the field the package of clinical services for sick children, known as the “Integrated Management of the Sick Child”. Work should continue on evaluating the potential of a “Healthy Schoolchild package”, including control of helminth infestation in children of school age, and on a “Healthy House package” of interventions to design and modify the physical environments of homes for maximum health, including improved shelter, safe drinking water and proper sanitation. Basic research on child development is desirable to better understand not only the physical maturation process, but also the determinants of intellectual development and ethical behaviour, that is, the sense of integrity, non-violence and responsibility for self and others.

**The human life process** needs to be better understood, at every age, from infancy and childhood, through adolescence to adulthood and old age. More research is needed on improving parenting skills and nurturing child development. Adolescent health is important because adolescence is a time when young people engage in critical interrelated behaviours which have major consequences for their current and future health. These behaviours include: early use of tobacco, alcohol and other addictive drugs; changes in eating habits; risk-taking, accidental and intentional injury or violence; suicide and attempted suicide; and irresponsible, unprotected sexual relations resulting in too-early and unwanted pregnancy and childbirth; and sexually transmitted diseases, any and all of which may have life-long adverse health and social consequences. Research is needed on problem identification, development of assessment tools, and means of effective intervention. Research on lifestyle factors, social attitudes and interactions among adolescents, adults and health providers can benefit from new techniques, such as the “narrative research method” and role-play among young people themselves. What contribution can be made by youth organizations, educational institutions, religious and social associations, and the public and private

sectors? Only sharing of practical research and experience can answer these questions. A commonplace truth is that young people are the future, and their health will carry over into productive adult life.

**Occupational health and safety** continues to concern largely adult working populations, in agriculture, industry and other occupations. Leading health risks are: respiratory diseases, musculoskeletal disorders, occupational cancers, and injuries. It is desirable to obtain data on doses and health risks for biological monitoring of exposure to dusts and chemicals at work. Research is needed on improved measures for medical screening of exposed workers. Psychosocial factors and stress in the workplace deserve research attention. Operational research is needed to design occupational health services and appropriate integration of health care for workers in national health systems using the primary health care approach.

**Women's health and development** is a new area for research focus, given changing societal values and greater presence of women in the workplace, educational institutions, policy and decision-making, and in provision of health care. These developments call for application of a gender perspective in health research, policies and programmes. Especially in poorer countries and communities, experiments in new financing schemes, education and employment opportunities for "empowerment" of women deserve support. Results should be widely shared, nationally and internationally. Design of health systems and services should reflect women's specific needs, perspectives and participation, particularly in respect of nutrition and reproductive health. Research is needed into the risk factors, consequences and means of preventing or mitigating violence against women, social discrimination, sexual exploitation, and certain unhealthy practices or abuses of the person, such as female genital mutilation.

**Health of the elderly** is rapidly becoming a major issue for research and strategic action, in view of the greater longevity and corresponding older age structure of populations in modern societies. The goal is not merely to "add years to life", but to "add life to years". The means and costs of attaining this ideal of healthy aging constitute a challenge of almost crisis proportion for the next century. Research is needed on ways of ensuring that elderly persons remain physically, mentally, emotionally and socially active, responsible and self-reliant for as long as possible, and that they have access to appropriate, affordable health care, services and support, and can face the end of life with dignity, and free of unnecessary suffering. This latter objective raises complex social, legal and ethical issues for consideration. Research and exchange of experience on different forms of health care and services for the elderly are essential, including different forms of home care. There is a need for better means of handling chronic respiratory ailments, including bronchitis and emphysema, as well as long term cancer, heart disease and diabetes in the elderly, and providing palliative care. Specific areas for research include studies on osteoporosis, age-associated dementias and determinants of healthy aging. Basic research in molecular and cell biology and genetic science offers promise for better understanding the aging process, and in the long term the possibility of ensuring a longer, and above all healthier, life-span.

**Reproductive health and family planning** research is absolutely essential to health and human development entering the Twenty-first century. Across most of the globe, sheer population size, rate of growth, density and migration constitute together the most pervasive and influential factor or determinant underlying and multiplying the adverse effects of other major determinants and conditions that threaten human health, welfare and development, namely, overcrowding, poverty, shortage of food, water and energy sources, disease transmission, environmental pollution and

destruction of habitat. Most life saving and humanitarian interventions actually exacerbate the underlying problem, rather than mitigate it. Excess fertility is a major problem for family health. Too many pregnancies, too early and too often, or unwanted and too late, are a serious health risk for mothers and children. Much as children are a source of joy and human value, too many children often burden a family's ability to provide child care, attention, food, water, housing, clothing, education, developmental activity and emotional support. Lack of access to and choice of safe, effective and affordable means of fertility regulation is a serious health risk and one that undermines healthy and responsible sexual relationships. Research is needed for attainment of "reproductive health" in its fullest sense, applying to every stage of life from adolescence through old age, and in accord with local conditions, law and culture.

The WHO programme on Family and Reproductive Health together with the co-sponsored Special Programme of Research, Development and Research Training in Human Reproduction (HRP), aim at four overall goals:

1. To enable people to experience healthy sexual development and maturation and have the capacity for equitable and responsible relationships and sexual fulfilment;
2. To enable people to achieve their desired number of children safely and healthily, when and if they decide to have them;
3. To enable people to avoid illness, disease, injury and disability related to sexuality and reproduction, and receive appropriate care when needed; and
4. To enable people to be free from violence and other harmful practices related to sexuality and reproduction.

**Fertility control technologies** continue to be central to successful reproductive health and family

planning programmes. Further research is needed to assess the safety, efficacy and use of existing methods and to develop new and improved methods of fertility regulation. High priority for research is the development and testing of new monthly injectable and/or oral contraceptive preparations. Data should continue to be collected and screened for contraceptive safety, particularly against possible risks for cancer. Antiprogestogens show potential for emergency contraception. If termination of pregnancy is necessary it should be safe, the ultimate goal being to eliminate unsafe abortion worldwide. Improvements are needed in design and low-cost production of condoms and intrauterine barrier devices. Work should continue on new methods for the regulation of male fertility. Research to develop birth-spacing vaccine should be pursued, taking advantage of new knowledge and use of monoclonal antibodies and molecular genetics techniques. Methods for the "natural" regulation of fertility need to be further explored, including study of lactation, hormonal activity, rhythm and other methods. Research is needed on inexpensive and simple methods or devices that can be used in the home to measure biochemical or biophysical markers of the fertile period. Research should also be addressed to the other side of the coin, that is, the causal factors and means of prevention of infertility, including related sexually transmitted diseases. Operational research is needed to develop approaches to broadening choice of methods of fertility regulation and ensuring their provision through high quality and sustainable reproductive health services responsive to need. Research is needed on how to raise awareness and ensure informed, responsible decision-making, especially among young and under-served people. Research capacity, health services development and policy making deserve strengthening to enable people to promote and protect their own health and that of their partners as it relates to sexuality and reproduction, and to exercise healthy family planning in an effective and culturally acceptable manner.

#### 5.4.4 Environment and Health

**Environmental threats to human health** are legion. Traditional hazards, related to poverty and underdevelopment, include: lack of access to safe drinking-water; inadequate basic sanitation in the household and the community; food contamination with pathogens; indoor pollution from cooking and heating; inadequate solid waste disposal; occupational hazards in agriculture and cottage industries; natural disasters, including floods, droughts and earthquakes; and disease vectors, mainly insects and rodents. Modern hazards, related to development and unsustainable consumption of natural resources, include: water pollution from populated areas, industry and intensive agriculture; urban air pollution from motor cars, power stations and industry; solid and hazardous waste accumulation; chemical and radiation hazards following introduction of industrial and agricultural technologies; emerging and re-emerging infectious disease hazards; deforestation, land degradation and other major ecological change; and climate change, global warming, stratospheric ozone depletion and transboundary pollution. Research must address and find improved means of control of all these threats.

“**Driving forces and pressures**” underlie the environmental threat situation. “Driving forces” include population growth, economic development and technology; “pressures” include production, consumption and waste release, for example. Although exposure to a specific pollutant or other environmentally mediated health hazard may be the immediate cause of ill-health, the “driving forces” and “pressures” leading to environmental degradation may be the most effective points for controlling specific environmental health hazards. Population dynamics multiplies the effects of all other determinants and factors. In addition to research on reproductive health and family planning considered above, strategic research is needed to better understand the processes of population growth, concentration, urbanization and migration,

as well as their relationships to poverty and ill health. It is possible to validate and determine the conditions for attainment of the “demographic transition”, that is the shift from (a) near-zero population growth at high death rates and high birth rates, with low life expectancy, through (b) the population explosion, to (c) near-zero population growth again at low death rates and low birth rates, with long life expectancy? Although the problem of “limits to growth” is ultimately a global one, the more proximate crisis is one of societal and geographical maldistribution of growth and resources. The vast continent of Africa is thinly populated overall, and yet it contains areas of extreme concentration of population, poverty and depletion of resources. Population movement, mainly from rural to urban areas, but also rural to rural, is driven by economic entrapment, unemployment, social deprivation and hunger. Migrant populations seek jobs, land, water, housing, material goods, transport and communications, and thus a hoped-for better standard of living. The solutions to these problems will require intersectoral cooperation and research.

**Urbanization** is a major trend in most modern and developing societies. Cities generate a large part of a nation’s economic activity, offer employment and commercial opportunities, and promise recreation and other advantages such as better education, light and power, health and social services. Urbanization often outpaces these promised opportunities, leading instead to poverty, overcrowding, pollution, exhaustion of local resources, and therefore declining health. Can these trends be reversed? Intersectoral research and exchange of operational experiences are needed not only to solve these problems within cities, but also and more fundamentally, to explore ways in which rural employment, standards of living, recreation, education and health care can be improved in rural and underserved areas, thus holding and attracting populations, and ensuring a more equitable

geographical and social distribution in relation to available land and natural resources. Operational research and exchange of experiences in developing “supportive environments for health” approaches include initiatives for “healthy cities”, “healthy villages”, “healthy islands”, “healthy workplaces”, “healthy houses” and “healthy schools”.

**Safe water supply and sanitation** continue to be a major research priority. Early in the next century, it is to be expected that many cities and populations will face an absolute lack of sufficient water resources to meet basic needs. Insufficient and unequal access to safe water is one of the leading attributes of poverty. Competition for limited water supplies may become a cause of civil strife and conflict between countries. Climate change will have particularly disastrous effects on water supply in many countries, from flood to drought. Research and exploration is needed to find new sources of water supply, including improved, cost-effective means of converting sea water to fresh water, and extracting salt from inland water sources, to make potable water. Research is needed to develop improved, cost-effective ways of protecting, managing, treating, conserving and transporting water, avoiding leakage and other wastage, and recovering, reprocessing and re-utilizing used water. Low water-use sanitary and irrigation systems, for example, can significantly will reduce water use. Methods of controlling water quality, purity and safety must be improved and made more widely available, together with wastewater treatment and sanitation.

**Environmental hazard monitoring and control** must be strengthened to safeguard water, air and land. The measures mentioned above to ensure water quality and use will help control food and waterborne or water-related diseases such as dysentery, cholera and other diarrhoeal diseases, as well as malaria, schistosomiasis, filariasis and encephalitis, and also to screen against chemical pollutants in food and drinking water, such as arsenic, lead, mercury, nitrates and pesticides. Air

pollution is a major environmental health problem requiring research, monitoring and control. Technical solutions must be found to reduce atmospheric pollution from agriculture, mining, manufacturing, chemical production, petroleum refining, metal industries, power, transport and trade. In some countries, auto-emission standards and catalysers have made a significant impact on reducing carbons and ozone in the atmosphere. Indoor pollution derives from outdoor sources, and from indoor use of fuel, cleaning products, paints and chemicals, as well as tobacco smoke and radiation. Research is needed on air quality management in industry and in the home. Inadequate solid waste disposal carries risks of a range of infectious diseases and toxic exposures. Means must be found and applied to process and possibly recycle municipal wastes such as vegetable matter, plastic, rubber, metals, textiles, glass, paper, wood and other materials. Special attention must be given to the safe use and disposal of organic compounds such as DDT, polychlorinated biphenyls, furans, chlordane, heptachlor, aldrin, dieldrin and endrin. Health care waste is becoming an important environmental health issue; new and better ways must be found to process pathological waste, infectious materials, syringes and medical equipment, pharmaceutical and chemical wastes, and radioactive materials. Radiation hazards from nuclear power accidents and waste disposal must particularly be watched. Following the Chernobyl accident, studies should continue on haematology, thyroid effects, brain damage in utero and oral health. Research is advancing, but without clear outcome, to design a new generation of “inherently safe” nuclear reactors. The International Programme on Chemical Safety should continue work on chemical risk assessment, monitoring and management. Basic research is needed to understand the combined effects of multiple toxic exposures in the environment, especially as they affect the immune and endocrine systems, and as they contribute to allergies, cancers and other conditions of disease and ill-health. What is, for example, the adaptability and capability of the cell repair and cell renewal system? Toxicokinetic and

dynamic studies on environmental effects on homeostasis in relation to dose, dose-rate and the kinetics of complex chemical interactions are to be recommended. Research is needed to develop appropriate indicators and methods to describe and monitor exposure to and effects of complex mixtures of environmental threats to human health.

**Hazard control technology and equipment** represent a fertile field for scientific invention, innovation and commercialization. There is a need for design and use of improved biogas and biomass stoves, burners and lights to reduce power and fuel consumption as well as air pollution. Better heat pump technology is needed for space heating. Photovoltaic energy conversion systems can reduce emissions and dependence on other power supplies. Although solar heating systems are in increasingly widespread use, they are not particularly efficient for larger community applications, and better means of focussing solar energy for both large and small scale applications could be envisaged. Catalytic converters and lead-free petrol are increasingly available and will replace air pollution from vehicle emission. Eventually, more efficient electric vehicles will replace conventional internal combustion engines. Alternatives to CFCs will help slow stratospheric ozone depletion. Use of fibreglass cabling for telephone lines will save copper. New alloys and plastics in manufacturing will reduce waste. Biological pest control methods will reduce toxic chemical exposure. These and other technological innovations will offer opportunities for commercialization that contribute significantly to human health and environmental protection in the next century.

**Saving planet earth** is, ultimately, concordant with saving humanity. The recent realisation of the communality of genetic origin of all forms of life, and their dependence in turn on organic and inorganic chemistry and physics, are reminder of the essential unity and interdependence of all on this planet. It has become the responsibility of mankind, if only from self-interest, to conserve natural resources and biodiversity. It is in mankind's own interest to preserve the natural purity of land, water and air, of forests, plant and animal species, and pass these on intact to future generations. Efforts to protect the environment must be local, sectoral, intersectoral, national and international, balancing sometimes competing interests in economic development and trade with those of human and environmental health. Current examples of successful international agreements affecting environment and trade are the Montreal Protocol to protect the stratospheric ozone layer, the Basel Convention on transboundary movement of hazardous and other wastes, the Convention on international trade of endangered species, the Biodiversity Convention, and the London Guidelines and FAO Code of Conduct on trade in chemicals. All of these international agreements to protect the environment and human health have to be supported by epidemiological studies and basic and applied research, to assess the nature and extent of the problem, causation, interrelations and effects, and to envisage, propose and test alternative policies, interventions and means of solution or enforcement. Research in environmental conservation is, ultimately, an investment in long-term human health.

### 5.4.5 Food and Nutrition

**Malnutrition** will continue to be a major problem well into the Twenty-first century. Many countries and poorer populations will be faced with a chronic shortage or even absolute lack of sufficient, nutritious food. The food availability and security situation will be adversely affected, and even compounded by, other “driving forces” or determinants such as population growth (“too many mouths to feed”), migration and urbanization, non-agricultural industrialization, consumption, and pollution, deterioration of agricultural land, lack of water, other adverse effects of climate change, maldistribution and emergence of diseases of plants, livestock and wildlife of land and sea. Over 30% of all children under five years of age in developing countries today are malnourished, and suffer from chronic hunger, protein-energy malnutrition, lack of essential micronutrients and diseases caused by unsafe food or unbalanced food uptake. The World Declaration and Plan of Action for Nutrition has set global goals to prevent famine and nutritional deficiency, but the research and development work to attain these goals must now be done.

**Strategies for action** proposed in the World Declaration and Plan of Action, implying research support and intersectoral, operational implementation, comprise the following:

1. Incorporating nutritional objectives, considerations and components into development policies and programmes;
2. Improving household food security;
3. Protecting consumers through improved food quality and safety;
4. Preventing and managing infectious diseases related to food;
5. Promoting breast-feeding;

6. Caring for the socioeconomically deprived and nutritionally vulnerable persons;
7. Preventing and controlling specific micronutrient deficiencies;
8. Promoting appropriate diets and healthy lifestyles; and
9. Assessing, analysing and monitoring nutrition situations.

**Food production and security** is a top priority for basic and applied research. New approaches in agricultural practices and industrial food production sciences, including biogenetic engineering, offer prospects for increased food production, wider ranges of robust, disease-resistant plants and animals, safer and more efficient food processing preservation, food chain and distribution. The introduction of new high-yield crop plant varieties, taking advantage of better natural and synthesized fertilizers, genetic engineering and hybridization techniques, as well as more efficient and mechanized means of intensive cultivation, irrigation, harvesting, rendering, air transport, and marketing - all these offer promise for better meeting the world’s quantitative and qualitative food requirements. Nevertheless, these “green revolution” technologies and approaches require assessment of their limitations and risks. Efforts must also be made to provide guidance, education and training in appropriate application of these advances, and to inform policy makers and the public. Large machine-dependent and capital - intensive agricultural projects may not always be the best way to go, for technical and social reasons, especially in developing countries. Smaller scale, private family-sized agricultural initiatives may provide longer-term sustainability, fuller employment, more equitable income generation, local nutritional benefits and environmentally-friendly land and resources management, provided

they are accompanied by appropriate policy and decision-making, technical guidance and training. Research and development efforts are needed to improve farming techniques, avoid over- or misuse of fertilizer, and prevent desertification and soil degradation, so as to protect the environment and sustainability of food production. Meeting global food needs will depend on directing more research and investment in agriculture, food processing industries and household food security strategies within the developing countries themselves, and with greater attention to social equity and a fairer distribution of income, food and other resources. Agricultural policies, food pricing, taxation, subsidies, food aid, land-use, and tariff and trade policies must be constantly re-examined for their likely impacts on health, and on social and economic development.

**Nutritional deficiencies** call for continued research attention. Although the causal factors of energy and protein deficiency diseases such as Kwashiorkor and marasmus, affecting an estimated 20% of children in developing countries, are generally well-understood, comparative research on why growth monitoring of infants and young children have been highly effective in some settings, but not in others, would be useful. Differences of view must be explored on the extent to which accurate assessment of body mass and growth is indispensable to interventions aimed at improving child health. Existing growth and nutrition charts require updating and adaptation to the situations of different countries and population groups. Studies are needed on infant feeding practices, starting with breast-feeding and on to complementary feeding as the child nears weaning time. Applied research is needed in some developing countries to develop a local, relatively low-cost vegetable-based weaning food, if not already available. Further studies of social and economic consequences of chronic energy deficiency and its correction will be useful, showing, for example, consequences of lack of energy on educational, home and community improvements.

Studies are needed for the determination of the effect of physiological and pathological conditions on the relative requirements for dietary protein and calories.

**Micronutrient deficiencies** deserve further research attention, to control nutritional anaemias, beriberi, pellagra, scurvy, rickets and other nutrient deficiency diseases. Iron deficiency anaemia is the most widespread nutritional deficiency in the developing world today. Prevalence studies will help stimulate responsive measures in many countries. Local research should identify the most feasible prevention methods, particularly the preference for fortification of one or more locally available staple foods. Iodine deficiency is a cause of endemic goitre and birth defects in certain geographic areas. Operational research is needed to find ways of overcoming obstacles to fortification of salt with iodine. Although practical means exist for vitamin A supplementation against xerophthalmia and other disease conditions, research is needed on methods that do not depend on the logistics of multiple oral doses of vitamin A, with emphasis on natural dietary sources or other feasible fortification. Knowledge must continue to be acquired and applied on the full range of vitamins and essential trace elements for human health and resistance not only to infectious diseases but also to “constitutional” diseases such as cancer, hypertension and stroke. These include: the vitamin B series such as riboflavin and folic acid, as well as ascorbic acid, vitamin D, vitamin E, and vitamin K, and essential minerals such as magnesium, zinc, copper, potassium, manganese and selenium. Although supplementation is feasible, and sometimes necessary, every effort should be made to ensure that these micronutrient requirements are normally met through the natural diet.

**Excess nutrition** or unhealthy food intake, is also an area for increased research attention. Obesity in infants, children and adults is a major and growing problem not only in industrialized countries but in many developing ones. Excess intake of fats, sugars and salts contribute to diabetes, cardiovascular

diseases and cancers. Research is needed on appropriate modification of diet at different stages of life, in infancy, childhood, adolescence, and adulthood, and for the elderly. More research is needed on the relationship of diet to heart disease and various forms of cancer. This should involve epidemiological comparisons between developing and industrialized countries which requires multi-national collaboration. Basic research is needed on the metabolic mechanisms that contribute to obesity and other nutritional imbalances.

**Food safety** is an area of major priority for basic and applied research and operational preventive action. Unsafe food exacerbates the problem of malnutrition. Many foodborne diseases initiate and intensify malnutrition, retarding physical and mental growth in children and grossly impairing quality of life. The global incidence of foodborne diseases is increasing in spite of efforts aimed at promoting food safety management throughout the food chain. Causative organisms include: *Campylobacter*, *Clostridium botulinum*, *Escherichia coli*, *Listeria*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio cholerae*, Hepatitis A virus, Rotavirus, *Giardia*, Helminth, and *Trichinella*. Research on the control of these agents, and on the safe, hygienic handling, preservation, preparation and consumption of food and drink, will go a long way toward ensuring human health and food safety. Close research and operational collaboration is called for among health personnel, food and agriculture officials, the veterinary public health professionals, the food and catering industries, schools and the scientific community. Chemical and radiation hazards in foods deserve research attention. In addition to chemicals

found in the natural environment or as inherent components of food itself, such as aflatoxins or poisonous mushrooms, potentially hazardous chemicals that are produced during cooking and processing, or sometimes as additives, include on the one hand colorants, artificial flavourings and other additives used intentionally in foods, and on the other hand chemical pesticides, agrochemicals, animal drugs, and heavy metals such as lead, mercury and cadmium, as well as PCBs used in industrial and electrical applications. Research is needed on the toxic properties of these chemical hazards, and the means of their reduction or avoidance to ensure food quality and safety. WHO's continued presence in and contribution to the Codex Alimentarius Commission and the Global Environmental Monitoring Systems (GEMS) is considered important. Finally, in food and nutrition programmes, as in virtually all other domains, programme evaluation is an important contribution that research can make. This research must include, but go beyond, "input" and "process" evaluation, to determination of the impact or "outcomes" of intervention programmes, using quantitative techniques when sufficient baseline data are available, as well as more qualitative approaches and expert judgement when they are not. Intra-country and international comparisons will be useful and assessments should be made on the complementarity of different sectoral actions and programmes, such as education, agricultural, industrial, environmental and social policies and interventions, health systems and policies, disease control programmes, and other actions taken to promote physical and mental health, and healthy behaviour.

#### 5.4.6 Mental Health and Healthy Behaviour

**Mental health** is assuming greater importance in both developed and developing countries, and therefore deserves increased priority for research and operational action. Although mortality from mental disorders is low, the burden of morbidity is high.

Upwards of 10% of the global population is estimated to suffer from some form of mental or neurological disorder at the turn of the new century. Some of these disorders are due to internal, physical or psychiatric factors; others are due to, or compounded by, external

stress factors. The vulnerability of millions of people to mental illness is heightened by cultural change, social upheavals, wars, ethnic conflict, overcrowding, pollution, destruction of habitat as well as unemployment and psychosocial stress in the workplace. These external stresses also translate into substance abuse, family problems, child abuse, violence, crime and other forms of "unhealthy" behaviour, which then become both causes and effects of mental ill-health. Research into all of these factors is needed, to better understand their causes, effects and means of modification, and to develop strategies for the control of mental and neurological disorders and of psychosocial problems of major public health importance. WHO's research rightly focuses on knowledge about the types, frequency and management of psychological problems most frequently seen at the primary health care level, especially in developing countries.

**Schizophrenic syndromes** are only partially understood and occur in 1 to 2% of populations. Schizophrenia is characterized by disturbances in thought, perception of reality interpersonal relations and psychomotor behaviour. Genetic, biological, cultural and psychological factors seem involved. Similar schizophrenic syndromes exist in all cultural settings, but the course and outcome of disease show significant differences between countries - patients in developing countries having on the whole a more favourable course and outcome than their counterparts in the developed ones. Further research is needed to determine why this is so, and to draw implications for case handling and treatment. Basic research is necessary to understand the nature and extent of the genetic basis of schizophrenia, and to develop new means of therapeutic intervention at the molecular biology level. Immunological studies have shown that schizophrenic patients and their relatives often have high levels of serum antithymic activity, suggesting that ATA may be an indication of high risk for the disease, although it is not by itself the causative factor. Antipsychotic drugs do exist and appear to work by blocking postsynaptic dopamine receptors, but adverse side effects may be experienced. Improved drug

therapies will allow most patients to resume normal lives, especially when accompanied by psychosocial support, vocational counselling and participation in social activities. Gene therapy is a long term possibility. Guidelines for diagnosis of Schizophrenia, patient management and therapy need to be developed and adapted for use in different cultural settings at every level of the institutional system, right down to the primary health care and family levels. Research is needed on other delusional or paranoid disorders, which may be of genetic or environmental origin, and may be aggravated by physical illness, head injury, alcoholism or drug abuse.

**Acute psychoses** are one of the most frequent reasons for admission to hospitals for mental health care. International comparative studies provide information that is useful for the psychopathological delineation of these syndromes, and will facilitate sociological, clinical and biological studies. Clinical research on these disorders, in which the personality is seriously disorganized, should determine whether and to what extent they are "functional" or "organic", that is, characterized by brain damage, disease or metabolic disorder. Anxiety disorders include phobias, panic disorder, obsessive-compulsive behaviour and post traumatic stress. They represent abnormal response to physical and psychological factors, conflict and stressful situations. However, clinical studies show that neurological damage such as brain lesions may be involved, and in the case of panic disorder, recent research evidence indicates that alterations in brain biochemistry especially norepinephrine, serotonin, and gamma-aminobutyric acid activity, may contribute to the disorder. Further research is needed to elucidate the underlying organic causes, the functional expression of these mental disorders, and the best methods for effective therapy. Dissociative disorders include identity disorder, fugue, amnesia, depersonalization and other personality disorders. Research is needed on certain eating disorders, more commonly found in "affluent" societies namely bulimia and anorexia nervosa. Practical guidelines are needed for patient counselling and supportive therapy.

**Depressive disorders** impose one of the highest morbidity burdens on quality of life of all causes of ill health in developed countries, and there is evidence of corresponding increasing trends in developing countries. Among these disorders, “unipolar” major depression is the most widespread and in severe cases can lead to suicide. The multiple causes of major depression are not well understood. Current research suggests possible genetic, familial, biochemical, physical, psychological and social causes. Depression is often secondary to other medical conditions, such as metabolic imbalances, endocrine disorders, neurological defects, cardiovascular diseases and infections. Research is needed on these relationships and on appropriate methods of treatment, including more effective antidepressant drug therapy. “Bipolar” manic-depression is strongly familial, suggesting the need for genetic research. Studies show low levels of dopamine and norepinephrine to be linked with depression, whereas high levels are associated with mania. New data suggest that changes in circadian rhythms that control hormone secretion may contribute to the development of “bipolar” disorder. Lesser forms of the disease include cyclothymic disorder and insomnia leading to occupational dysfunction. Guidelines are needed for diagnosis, case management, and therapeutic treatment of mental illness, for use at all levels of the health care system, and adapted to local cultural settings.

**Neurological disorders** of the central, peripheral and autonomic nervous systems are extremely complex and provide a significant challenge to the neurosciences. Brain and spinal cord disorders include meningitis, encephalitis, Huntington’s chorea, Parkinson’s disease, Myelitis, Alzheimer’s disease, as well as Reye’s and Guillain-Barré syndrome. Paroxysmal disorders include migraine headache and epilepsy. Appropriately, the immediate research priority for WHO’s assistance to developing tropical countries is epilepsy and other disorders due to the affection of the central nervous system by tropical infections, parasitic and other diseases, including meningitis, and by other environmental

noxae. Work on their prevention and treatment is to be undertaken simultaneously with neuro-epidemiological studies and dissemination of information. Basic molecular, biochemical and genetic research offer real possibilities for effective therapies for epilepsy, Huntington’s chorea, Parkinson’s disease, and Alzheimer’s dementia. New scientific breakthroughs will facilitate the design of highly specific and effective drugs for eliminating the cause, or blocking the effects of these abnormal conditions. For example, new research findings have elucidated the cause of atrophy and death of basal ganglia brain cells due to accumulation in the cell nucleus of insoluble glutamine proteins as a result of chromosomal “CAG repeat” errors in Huntington’s disease. The current research challenge, therefore, is to develop practical techniques for dissolving the balls of protein in the affected cells. Ultimately, gene therapy may provide the best solution. Immunological studies also should lead to a better understanding and treatment of a number of syndromes which represent an abnormal or auto-immune response to viral and other infections. Research is needed on peripheral nerve disorders including Bell’s palsy, neuritis and neuralgias. Further research is needed on the biochemical, immunological, genetic and environmental aspects of neuromuscular disorders such as myasthenia gravis, amyotrophic lateral sclerosis, and multiple sclerosis. More developed countries may have the resources also to address the leading congenital anomalies, such as cerebral palsy, hydrocephalus, cerebral aneurysm and spinal cord defects such as spina bifida. Among “new” diseases of the brain are chronic fatigue syndrome and transmissible spongiform encephalopathies or “prion” diseases, especially the new-type variant of Creutzfeldt Jakob’s disease. Although most of these disorders are not of high priority for developing countries at this time, and most third world institutions do not have the means to undertake such “high tech” research, the information networking of scientific institutions will nevertheless ensure better epidemiological assessment worldwide, as well as opportunities for sharing of knowledge, and

eventual earlier application in health work. It is a challenge to our will and to our ingenuity to find ways that sophisticated technology, from brain scanners to gene technology, can be made available and affordable for all.

**Child mental disorders** need particular research attention. In addition to the conditions outlined above, common disorders of infancy childhood and adolescence include mental retardation, tic disorders, autism, and attention-deficit hyperactivity disorder. In about 75% of cases, predisposing factors, such as deficient prenatal or perinatal care, malnutrition, poor social environment, and poor child-rearing practices, contribute significantly to mental retardation. Down syndrome, which correlates with older parental-age, usually results from specific chromosomal aberration. While much has been learned about child support, as well as surgical correction of some related heart defects and other congenital abnormalities, the ultimate solution probably lies in basic research leading to gene therapy. The same is likely to be true for certain congenital motor and vocal tic disorders. The causes of autistic disorder are in some dispute but research findings suggest brain dysfunction, possibly resulting from trauma, disease or a structural abnormality. Autistic disorder also has been associated with maternal rubella, untreated phenylketonuria, tuberous sclerosis, anoxia during birth, encephalitis and fragile X syndrome. In addition to research on prevention of these factors, guidelines are needed for institutional and home care and support. Studies show that attention-deficit hyperactivity disorders in children may result from disturbances in neurotransmitter levels in the brain. In addition to basic research on this disorder, research on educational methods, counselling and drug treatment is desirable. WHO and partners should continue work on multi-country comparative studies of common mental disorders in childhood, classification of abnormal conditions, support to planning of national child mental health programmes, and development of indicators of psychosocial growth and development. Basic

research faces the long term challenge of understanding the neurological and chemical functioning of the brain, including memory, maturation, intellectual capacity, malfunction, brain damage, loss of function and brain death.

**Dementias** are of emerging concern, especially because of the extended life expectancy and therefore increasing age structure in most countries. Research continues to be needed to develop data about the epidemiology of dementia and to test methods which can be used in the assessment of mental disorders in old age. Attention is also to be given to issues related to the assessment, frequency and outcome of mild cognitive disorders because it appears that these disorders are more frequent and disabling than was previously thought. They are present as a leading symptom in a variety of diseases and conditions. New and improved drugs are needed for stabilizing or reversing loss of memory and related disability or loss of function. It is likely that such treatments will promote good mental faculty and sense of well being into very old age. Alzheimer's disease, or primary degenerative dementia, accounts for nearly half of all dementias. Research findings indicate that factors implicated in Alzheimer's disease include neurochemical, genetic and environmental factors. Experimental drug therapies are making progress, and the long term solution may lie in basic neuroscience and gene therapy. The knowledge gained from basic and applied research on dementias should be translated into practical therapeutic technologies and approaches, and included in guidelines for care of the elderly, as an integral part of the primary health care system.

**Substance abuse** is reaching virtual pandemic proportions, especially in "affluent" societies. Addictive substances include alcohol, tobacco and illicit psychoactive drugs, and may sometimes involve the misuse of volatile solvents and medicinal drugs. Alcohol dependent syndromes are linked to other problems ranging from cirrhosis and heart diseases to work and traffic accidents and violence.

Tobacco use leads to millions of premature deaths each year. Drug use is marginalizing substantial proportions of vulnerable young people in their potentially most creative and productive years, with enormous health and social consequences. Injecting drug use generally entails greater risk than non-injecting, and the risks of overdose are high in both. The extent and severity of the health risks and problems associated with amphetamine-type stimulants are not sufficiently well understood. Basic social and epidemiological research is necessary, since lack of understanding is a major obstacle to effective preventive measures. Research is needed on: primary prevention approaches which seek to prevent problems from occurring in the first place; health risk management to prevent emerging or existing problems from being exacerbated; treatment and care of individuals who are already experiencing significant harm as a result of their substance abuse; rehabilitation; and regulatory control measures to strengthen and support legislative action. International comparisons and exchange of practical experiences, as in WHO's "Healthy Cities" project, will be of great benefit. Programme action can be accelerated through advocacy, information collection and dissemination to raise public awareness and provide essential information support to policy makers for decision taking. Basic research is needed on alcohol, tobacco and drug toxicology, chemistry, and physiological effects. Research is needed to find new and more effective drugs for the treatment of and withdrawal from dependence. Treatment protocols should be developed for local cultural situations. WHO and partners should use the results of all such research in their continuing efforts to promote, and strengthen country capacity for research, particularly in the areas of epidemiology, prevention, treatment and programme evaluation.

**Healthy behaviour** should be the end-product of the research and development efforts outlined above. Particular research attention must be given to understanding the nature, root causes, and means

of prevention of anti-social behaviour, including violence, especially against women and children, as well as excessive risk-taking, leading to loss of life and injury to self and others, and failure to adopt healthy behaviour. What, for example, are the links between poverty, violence and loss of human values? Research is needed on how participatory community approaches and social support, involving young people and vulnerable groups, can reverse these adverse trends and their negative consequences. Health promotion and education are major instruments for change and understanding; people should know what it takes to be healthy, and they should want to be healthy. This may require some research and open-discussion on what is "health", and what is social "disease", in the local cultural context. What are the factors understood to contribute to "health"? How can you measure that? If not directly, then are there "proxy" indicators? If people "feel good", are they healthier? In an increasingly "free" society, what is the role of social conscience, ethics and sense of responsibility to self and others? Perhaps it is this basic understanding which is the primordial subject of inquiry, and if it can be reached, then perhaps it offers the greatest hope for the attainment of human health in the Twenty-first century.

Suicide and parasuicide (or attempted suicide) constitute a huge public and mental health problem which is on the rise in almost all cultures and countries, especially in youngsters and elderly people. According to the World Health Report 1998, the last available mortality data by suicide amount to 835,000 deaths per year world-wide. However, the real figures are certainly much higher since many suicide deaths are registered, for cultural reasons, as accidents. Three times more women than men attempt suicide, while three times more men succeed. The occurrence of parasuicide is estimated to be 10-20 times higher than that of completed suicide. Suicide and attempted suicide are the main manifestation of self-inflicted violence. They are often preceded by depressive or compulsive disorders: a better knowledge and taking into

account of the risks of acting out is a prerequisite for prevention. Likewise, the risk of repeated attempts is high and should be cared for. In order to better understand and prevent suicide, interdisciplinary research is badly needed, including behavioural and psychosocial research, as well as basic research on brain functions, hormonal factors, neuro transmitters and receptors of depressive and compulsive disorders.



# 6 Research imperatives and opportunities: Methodological needs

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- ◆ Locating, utilizing and improving existing knowledge
- ◆ Where and what new methodologies are needed?
- ◆ Health measurement and monitoring
- ◆ Health data interpretation
- ◆ Modelling and simulation
- ◆ Priority setting methodology

This chapter considers why and what kind of new methodologies are needed in support of research to aid the cause of improving global health. Some of the major requirements are for new techniques: to circumvent the difficulties of obtaining sufficient and reliable data for studying global health; to investigate the relation between behaviour and health; and to explore important intersectoral effects involving health. Special opportunities are offered

by recent technological advances which could allow fuller use to be made of a greatly under-used resource - expert observations, insights and judgements about health in communities. These and other advances can contribute to research in specific areas: the measurement of health, health data interpretation, modelling and priority setting. Lines of research and development and ways of using the resulting methodologies can be identified.

## 6.1 Locating, utilizing and improving existing knowledge

The recognition of an existing significant health problem means that an effective solution to it is not in force, whether or not a solution exists. The situation may be due to the absence of any evident solution; to the unfindable cost of doing anything about the problem; to the absence of suitable human resources; or because no one is motivated to tackle it. The recognition of health deficits and their origins does not automatically indicate solutions or specify any research that may be necessary. Identifying apparent gaps in knowledge may indicate what to look for; the Internet and E-mail make searching for existing knowledge (and contacting possible sources of expert advice) much easier than hitherto.

As shown in previous chapters, the newly emerging dangers to health, as well as the intransigent problems to which no solutions have yet been found, are often complex, with many interacting dimensions. Finding solutions will require the collaborative efforts of specialists from

different scientific disciplines. Ideas, information and multi-disciplinary knowledge must be shared, leading to the development of collaborative research. The question is: how can such collaborative research, encompassing and bridging multidisciplines, be undertaken?

The arrival of the Internet, electronic mail and the World Wide Web has made the exchange of ideas, information, research data and research papers easy, economical and rapid. This is a potent methodological development that could be used to stimulate global health research, because it greatly simplifies research collaborations. Communication can be established, discussions continued with the aid of (at present) somewhat rudimentary videophone images of the persons communicating, and documents worked on cooperatively. Indeed, the development of the technology of computer supported cooperative working (CSCW) on tasks, including the preparation of research reports and papers, is now well advanced.

With the aid of further experience from other fields in which these techniques are actively in development and use, Internet technology should substantially reduce the isolation of workers distant from the main centres of health research. Careful consideration must be given to the manner in which these potential connections and collaborations could develop, in order that the communication serves as a support for research rather than as a substitute. Further research on the CSCW methodology is likely to pay appreciable dividends.

The existence of possible solutions to existing problems should not be overlooked. However, searching for available solutions - or those that might be transposed for the specific problem - does seem to demand the help of experts having wide experience in finding possible solutions to problems in many disciplines. The collaboration of those experts who can recognise the possibilities of developing specific knowledge to solve particular problems, and those most familiar with the problems, would seem to be crucial in planning how to achieve the necessary improvements in knowledge. Mechanisms are required that will bring together the appropriate holders of knowledge, and motivate their collaborative attack on unsolved problems in global health.

Nevertheless, available knowledge is sometimes not used, even when its existence is known; why is this? It may be partly a matter of perceptions: perhaps economic (e.g., estimated cost may be too great; judgements about cost in relation to benefit may have been made by inappropriate authorities); perhaps anticipated problems of implementation, including any necessary modifications for local circumstances; or perhaps a matter of motivation due to an absence of prior experience of inward transfer of knowledge, technology or know-how, or a reluctance to use ideas from elsewhere.

In any event, the practicalities of making judgements and decisions about the use of available knowledge seem likely to be involved, as are

behavioural factors, operating at the personal level and in the way bureaucratic systems function in seeking information, taking decisions and implementing the outcome. Reasons may change with circumstances. But because of the importance of this matter, clear understanding is needed and further systematic research is required.

Within WHO itself, the need to access available knowledge takes a different form. First, there is a wealth of knowledge and experience that has been gained by its professional staff members and external advisors in course of, for instance, missions to various countries. This often includes valuable insights into country circumstances, economic situation, sociocultural factors and other local details that are not normally part of a formal report. Further, the content of mission reports and also the reports of external expert committees and of individual experts needs to be available in such a form that staff members of the Organization can maintain an updated idea, both of what the Organization knows and of the broader implications of their own work.

This indicates the need for a specific project, having two main targets:

1. to provide easy access within house about what the Organization „knows“, encapsulated in summarised formal reports, extended to capture informal facts, perceptions and judgements obtained by professional staff and external experts about the situation in a country, or about aspects of whatever topic their report concerns and,
2. to set in train a regular in-house practice of providing material for this purpose.

It would be hoped that, through making the stored material available on an intranet, it could and would be readily and regularly accessed by staff within the Organization, especially if it is made easy for staff to identify documents that are particularly relevant

and important for them. It could also improve the opportunities for staff members to see the wider implications of their work for other parts of the Organization, and vice versa. The effect of this project would be to implement the first steps towards setting up a “collective memory” and a “collective intelligence” for WHO.

To ensure that this process can become “second nature” within the Organization, it is regarded as vital to make full use of the spoken word in capturing this information, so that easy informality can be

maintained. This would have the effect of making it easier than otherwise to express the understanding and insights the experts have been able to gain, and for the nuances of meaning to be captured effectively. At a later stage, the stored information should be structured into a “knowledge base”. By searching out the documents within which specific topics appear, the stored information can be further explored and enhanced with the aid of “knowledge based” software to yield more general inferences; this would constitute a gain in “knowledge”, derived from the available information.

## 6.2 Where and what new methodologies are needed?

New research methods often arise spontaneously with the advance of knowledge. In the case of global health research however, certain explicit needs can be identified, in particular: new methodologies for behavioural research, for intersectoral research, for modelling of health systems within the socioeconomic framework, for the exploitation of

expert judgement in the arena of health measurement and for the methodology of collaborative research within a “virtual research centre”, i.e., between distributed laboratories, collaborating in their research with the aid of the Internet and other communication technologies.

### 6.2.1 Methods for inter-sectoral research

Health status depends not only on biological aspects, but on a broader range of other factors that clearly influence health, such as nutrition or the impact of the physical environment. Certain of these factors have been the subject of research but undoubtedly require more attention than they have been given hitherto. But other possible factors affecting health remain very largely unclarified; it might be said that those of specifically socioeconomic origin constitute largely uncharted territory for scientific investigation. Research in this area is regarded as both timely and important, but the techniques for investigation are limited.

Relevant research questions can readily be defined; for example: how the social environment affects health: including the effect of domestic or

local violence, civil disturbance and wars; “borders” health; social aspects of urbanization; the influence of the economic environment; unemployment; economic migration.

In order to study such matters, methodologies for identifying and studying interactions between health and activity in other sectors must be developed. One fundamental requirement is a method by which to measure or otherwise evaluate variables in non-health sectors that could be relevant, and correspondingly in the health sector. In detail, this requires first, the identification of variables in non-health sectors that can be used as indicators of any suspected health effect and second, the identification of variables in the health sector that reflect this influence.

However, many of these variables cannot be expressed numerically. One can envisage, for instance, that a combination of circumstances in a community's socioeconomic situation might constitute the non-health sector "variable"; such circumstances could only be expressed as linked statements of fact. The health sector "variable" under examination might concern, for example, psychiatric illness. If the incidence was in question, the variable would be described numerically; but if the interest was in the nature and related circumstances of the risk of psychiatric illness, numerical measures would not necessarily apply. Methods for analytical, rather than subjective, study of such possible relationships are needed. Research into "knowledge-based" techniques may meet this requirement.

Thus, "knowledge" considerations apply to economic and socioeconomic influences on health. Many elaborate econometric models purport to describe the economic system in a country. Their inadequacy in the context of how the economy, or indeed, any non-health sector affects health lies partly in their inability to handle important information that exists only in the form of semantic "knowledge". For instance, motivations derived from prior experience affect how individuals, families and communities use their resources. This could easily be expressed as a verbalised descriptive statement, but not directly as the mathematical expression that econometric models demand. In the study of what factors affect the motivation of people to seek and accept health care, non-health influences would seem to be crucial. These are difficult to study, yet expert observation and inference, organized within various 'knowledge-based' techniques, could

### **6.2.2 Methods for behavioural research**

The influence of behaviour on health is pervasive. "Behaviour" as a concept refers to human behaviour individually, collectively - in groups - and by society generally. It also includes the behaviour of personnel in the health services and in their contacts with one

constitute a useful support to research on such matters.

More generally, intersectoral research also will require means to handle non-quantitative information. The basis for inter-relating qualitative and quantitative data is well-founded in human psychology and other social sciences, but only in that restricted context. To meet the needs of global health research, qualitative data could, in principle, be better handled with the aid of technical procedures under the name of "fuzzy measures and fuzzy logic" although health research applications are limited as yet. (An interesting early example was the use of fuzzy variables in questionnaires designed to study the relation between social stresses, psychological factors and the incidence of coronary heart disease.) But within intersectoral studies, much relevant information comes in the form of "knowledge" rather than data, so the first step in developing general methodologies for intersectoral research is to provide "knowledge-based" techniques. More experience is needed in applying fuzzy variables and approximate reasoning in global health research.

Knowledge-based techniques depend on three elements: a scheme for provision of the basic information gained by experts, design of the "knowledge map" by which this information is assembled into a usable indicator, and the technique to incorporate the indicator - as a variable - into the wider framework of, for instance, an intersectoral model. Each of these elements needs further research and development. (See also the sections on "Health measurement", and "Modelling".)

another individually and collectively within the Organization, and the way in which the local or overall organization performs both routinely and in the face of large-scale disturbance.

Almost all health problems seem to have an underlying behavioural element. However, identifying important factors affecting health and studying the mechanisms objectively will again require major methodological developments. These will support and extend, if not - to some extent - replace, psychological and sociological techniques. It is envisaged that the most important techniques will be based on cognitive science, drawing upon computational logic, guided by - inter alia - anthropological expertise.

Understanding the mechanisms means, to take one aspect of peer group pressure as an example, to clarify how the education and psychological 'set' of an individual renders that individual more or less susceptible to health damaging behaviour patterns that are standard within a group. Insight of this type would be intended, not to provide a basis for designing "behaviour modifiers", but rather to see how motivations develop - with a view to, perhaps, "motivation modifiers" having potential for improving health.

While quantitative methods are well established in individual psychology and, to an extent in social psychology as well, these do not fully illuminate the pathways by which behavioural imperatives affect health. On the other hand, there is a multiplicity of potentially relevant factors, particularly in the social or household context, that can again be perceived by experts, although their complexity and number frustrate the unaided attempt to draw systematic conclusions. Expert perceptions can, however, readily be expressed as natural language statements; again the task is to develop techniques to handle extensive information of this kind in an objective way that will lead systematically to valid inferences.

Entire systems also have their "behavioural" characteristics. A recent study of the introduction of computerisation into a network of social data-gathering centres in an industrialising country found an extremely high reporting rate of equipment

failures. It emerged that, typically, the equipment had not failed; introducing computers into an organizational structure had not considered the social characteristics of the system. Within organizations, behaviour patterns in respect of the way people interact in carrying out their work appear substantially to affect the efficiency of the organization.

Even a Virtual Research Centre formed by the interactive collaboration of several laboratories will develop its own behavioural characteristics. And - a more immediate example - understanding the consequences of introducing new technology into a health system means understanding and taking account of "behavioural characteristics" of the system.

In brief, it is now believed that within organizations, behaviour patterns in respect of the way people interact in carrying out their work appear substantially to affect the efficiency of the organization. Formal methodologies for such studies are not well-known, if they exist at all. Developing and applying appropriate methods to develop "behavioural" models of health care delivery systems would help design more effective organisations. Such approaches could add an extra dimension to the analysis or design of health care systems at both small and large scale.

Within the behavioural field, individual, social and organizational, a number of key issues can be identified. It will be necessary:

- to identify health influencing behaviour patterns of and between individuals, families, social and community groups; personnel in health care delivery systems; policy-makers and researchers;
- to elaborate methodologies for objectively studying and analysing behaviour patterns and factors that cause or motivate individuals or communities to maintain, or to change, healthy or unhealthy lifestyles;

- to develop methods to monitor and control the communicability of health related behaviour (e.g., assess the effects of peer group pressure);
- to study the mechanisms by which societal discrimination puts people's health at risk (e.g., maternal smoking affects the health of a fetus);
- to study the effects of such factors as unemployment or lack of education on health related behaviour;
- to study the determinants of health-related behaviour according to origin (economic, political/military, cultural, religious, environmental, etc) or category (poverty, displacement, drought, unemployment, etc);
- to identify the circumstances in which it is possible and ethical to influence behaviour related to health;
- to utilize behaviour related simulators, models and scenarios as a means for forecasting likely future trends and for assessing short, medium and long term effects of possible interventions;
- to identify the reasons why established knowledge of social and behavioural sciences is not appropriately utilized.

## 6.3 Health measurement and monitoring

### 6.3.1 Visualizing health data

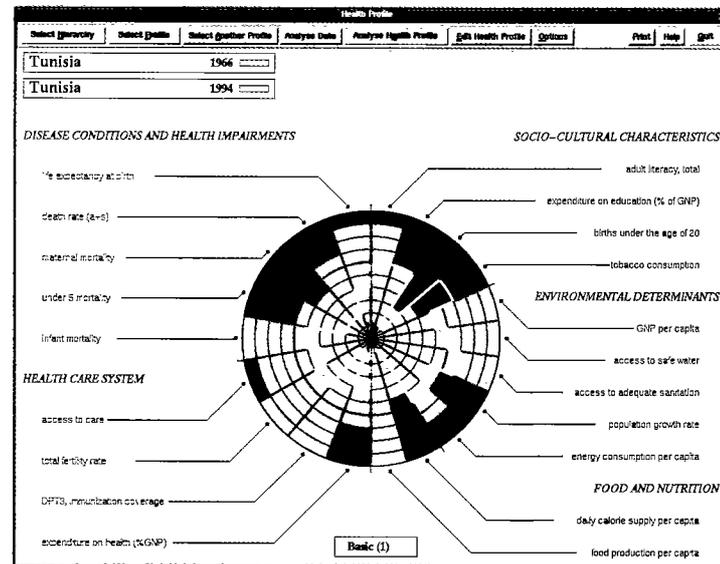
A broad view of the health status of a country in terms of measurable data about health - as distinct from the fundamental determinants of health - can be obtained using the Visual Health Information Profile (VHIP). This presents a composite visual display that is easy to interpret. But while the initial display uses highly aggregated versions of the data, it is possible to disaggregate step-by-step as far as the available data will allow, and to choose to focus on more of the detail of which the high level display is a summary. This is made possible because the VHIP is implemented on a computer display, and the software uses a database that is normally transparent to the observer, but immediately accessible. The Visual Health Information Profile can, for example, be used to represent: a) comparative health and other data over time; b) detailed information that can be called up from a richer data base, including expert statements; and c) comparisons between different countries, districts or communities within a country. (See **Figure 7.**)

Health deficits can be identified, and traced back to those parts of the data which give rise to the deficit observed. Trends with the passage of time can be shown. Hypotheses about inter-relationships between variables could be investigated using both traditional software statistical packages and visualization techniques with the human investigator. While the visual health information profile concept has been implemented and is an existing system, three targets for research and for the further development of the health profile approach are envisaged.

**The first target:** representing disease and its effects in terms of observable data: could probably be met by continuing development of the VHIP. This particular form of indicator offers the opportunity for the use of new techniques of analysis and interpretation of the complex data patterns that can be included. At its simplest, it provides an easily interpretable indication about trends in particular

aspects of health in any individual country, and also an easy way of making comparisons between countries. But also, various new hypotheses can be tested in an exploratory way by using the human ability to recognise patterns of relationships during rapid scanning through the profiles for different countries or different years, using various arrangements of the different contributing sectors. This is likely to be most helpful when unknown, non-linear relationships are sought; an example is the relation between nutrition level and say, cardiovascular disease which only emerges when economic development reaches a certain level. Once a possible relationship has been discerned, it can be formally investigated by established methods. Appropriate scientific techniques need to be developed to formalize this and other methods for analysis of the data in the specific VHIP form.

The **second target** aims to take account of the “multi-pathology” situation: that individual diseases do not necessarily occur alone. This is especially true, in old age and is commonly the case in developing countries that an individual suffers from more than one disease simultaneously. To represent the interconnections involved in the occurrence of multi-pathology needs a “map” - to be attached to the VHIP or other such indicator; it would probably take the form of a numerical model. Such a model is needed because, in conjunction with the VHIP, it would allow more realistic data about the burden of disease to be obtained and about the likely scale of response to particular interventions.



**Figure 7: The Visual Health Information Profile - application of the method for Tunisia: A time comparison 1966 - 1994**

The VHIP presents each of the five domains of health as a radial segment of a circular graphic display. Each of these segments is subdivided in several smaller segments representing a specific measurable of that health domain each of which is marked off in a 10-point scale in which 1 (periphery) is defined as a situation requiring improvement urgently, and 10 (centre) as a „satisfactory“ situation. At present, about 80 measurables are incorporated into the information system and others will be added in due course. The data availability, however, varies considerably between the 200 countries in the data base.

The totality of a country's health status is visually presented in a way that allows comparisons to be made between the five domains and their measurables in a variety of respects, between countries, or between the health status observations made in one country at different times. Such an analysis will result in the formulation of hypotheses as to causal relationships between the health domains and their measurables, which have to be tested by investigative studies.

It would be a necessary stage in the development of a comprehensive picture of health status.

But at the next stage - this is the **third target** - acquiring and utilizing knowledge about the multifactorial origins of disease - elements such as case numbers must give way to a new type of descriptor, representing fundamental knowledge that

links diseases to origins. Such fundamental knowledge could often take the form of verbalized statements of expert observations, beliefs and facts, derived from close study of specific communities, analyzed for inherent consistency. This is where the “knowledge map” methodology could contribute.

In practice, measurable data about health are difficult to obtain; such data are not always reliable,

and often incomplete, especially for the needs of research. Some technical tools are available to help correct errors and help estimate missing data, but they do not address the basic problem. Capturing adequate, reliable data is a constant challenge and new methods are keenly sought. A different approach can be considered: using expert observation and expert insight - which is, in any event, a poorly used resource.

### 6.3.2 “Knowledge-based” assessment of health

Valid observations about health aspects of a community, for instance, made by expert observers, and justifiable insights, would constitute real “knowledge”, even if this knowledge did not take the form of numbers. But it would be vital that these inputs be subjected to tests of consistency, and be handled objectively and systematically. Recent technological innovations and developments make it possible to make effective systematic use of verbalized “knowledge” expressed in the form of natural language. It is also possible to employ techniques that, in effect, allow the logical implications of such expert insights to be explored and understood. The use of such “knowledge-based” technologies and “knowledge maps” in the health field may offer the kind of development that is now needed.

Two aspects are required: “fuzzy measures and fuzzy logic” and “computational logic”. Fuzzy measures are a natural consequence of using “natural language” to express “knowledge”. But “fuzzy” does not mean “sloppy”. Rather, it provides a systematic way of handling the complexity of the system with which we need to deal, by allowing “uncertainty” in our descriptions and in our inferences. Computational logic is a means of using logic as a computer language, to handle the “meaning” of verbalized “statements” and to draw logical inferences from these statements. Put briefly, in the present context it is hoped to apply the methodology of computational logic to derive inferences and

implications from the observations and insights of expert observers, expressed in “natural language” and using “fuzzy measures” and “fuzzy logic”.

Specifically, there is a fundamental need for new and better health status indicators and for indicators to aid research on multisectoral interactions with health. The design of a class of “knowledge-based” indicators is therefore an important research target.

A “top down” design strategy (one of the approaches) starts with the high level indicator itself (for example, “community health status of the aged”) and, by cognitive analysis, decomposes this “concept” into its constituent elements, each of which is analyzed in turn, and so on until elements are reached that can be measured or observed. Such basic elements can be illustrated by, for instance, information about typical household arrangements for the aged, community support, physical capability, mental capability, extent of dependence, contribution to the work of the household, health history, prior occupational disabilities, endemic diseases in the community and so on.

Then the process is inverted, and the relations between the various fundamental elements - expressed as semantic statements of “knowledge” or other forms of relation - is used to infer the next higher level element, and so on. The totality of the linkages and the “knowledge” expressing how elements are related constitutes a “knowledge map”

of the indicator. The “knowledge map” shows how the “health status” of the aged in the community is “assembled” from the observation of basic facts, in the light of other expert insights about relationships. Accordingly, it would also indicate how these basic “determinants” act, and through what pathways, to lead to the picture of “health status” as described.

Understanding the nature of the “health status” indicator resulting from the “knowledge map” requires consideration of the dimensionality of the “high level inferences” generated by the “knowledge map”. One approach is to regard the health status indicator as having both positive and negative elements. Focus on the negative element. Aggregated measures of health deficits demonstrated by the “knowledge map” can be compiled into a “severity” element and a “rate of change of severity” element. These elements have different implications, would be used differently and for different purposes, and should therefore be treated as constituting two different “dimensions”

## 6.4 Health data interpretation

Some health-related data are time-varying (e.g., seasonal outbreaks), some vary spatially (e.g., cases of radiation sickness; breeding sites of insect vectors), some are both (e.g., the growth of case rates and spread of a communicable disease). Some data take the form of “point events” occurrences (e.g., cases of disease on a day to day basis; locations of cases within a city; locations of hospitals or health centres). Remote sensing and geographical information systems (GIS) provide the opportunity to link maps with other ground data so that, for instance, the location of new health centres and hospitals can take account of the spatial density and scatter of the populations concerned, the road or river network and any transport facilities serving the area for access.

This type of data can become the basis for useful research in certain problems. With sufficient reliable

in the indicator. The dimensionality would also be increased if it is necessary to take account of consequences that only occur in certain specific circumstances. These are due to “latent” factors and pathways that are only activated in certain circumstances. (For instance, the risk of malaria spreading in, say, an afforested region may be zero, even if the insect vector is already present, until non-indigenous workers, who happen to harbour and serve as a “pool” of the disease, enter the region. Again, if a given disease is successfully eliminated from a region by appropriate interventions, it may uncover another disease which is simultaneously present but masked by the first. The second is, in this sense, “latent”.)

Similar research developments are needed for the representation of other sectoral variables, for intersectoral studies, leading on to the development of methods to model the intersectoral interactions with health using “knowledge-based” indicators.

data about the spatial location of dwellings, schools, markets and also about the occurrence date and location of cases of a communicable disease, it is feasible to determine the “operational” - as distinct from the biological - mechanisms for the transmission of the disease, the evolution of its case occurrences and its spatial spread and translation. Pattern analysis is a tool in such studies, which have been carried out with, for instance, variola minor and measles epidemics, and feral rabies epizootics. Given possible outbreaks of communicable diseases for which neither vaccine nor antimicrobials are yet available, this kind of information could be used to plan geographical and community control procedures; it could also throw light on the “operational” characteristics of the spread of communicable disease.

The characteristics of insect vector movement can be tracked in some cases by satellite remote sensing, but in other cases and on a smaller scale, ground radar with supplementary assistance is needed. There are significant opportunities for research with such technology, in studying both the role of particular vectors in spreading disease and the behavioural characteristics of the vectors.

Pattern analysis is another methodology which has been developed in the context of several epidemiological problems. It highlights and attempts to explain the underlying systematic patterns, reflecting biological mechanisms that are not often visible in individual or collective records. Various

## 6.5 Modelling and simulation

Modelling means creating a representation of the structure and function of some real world system; simulation means using it to determine how the real world system would behave in a given situation. Success requires accuracy and adequate completeness in describing the system. However, a dominant feature of many global health problems is the complexity of the factors involved, of the pathways and systems by which they affect health and the consequential interactions with other, non-health, sectors.

Modelling and simulation research that aims to make a lasting contribution to reducing global health problems needs methodologies to assess health status, to assess the relevant factors affecting health, to describe potentially interacting variables outside the health sector and to tackle “complexity”. Much of the data and other information needed are not readily available. Many of the factors and variables may not be measured directly and in any case cannot be expressed quantitatively.

Complex systems do not yield to analysis by the classical approach of disaggregating their

methods have been innovated in the study of weanling diarrhoeal disease, the growth patterns of young infants, the spatio-temporal incidence of fetal abnormalities, the characteristics of blood pressure fluctuations in man and the effect of workload stress (and even of space flight) on physiological mechanisms. The methods rely on being able to recognize various kinds of features in the records. They allow the recognition of common systematic components underlying seemingly intractable variability and generally offer a useful basis for generating hypotheses that can be followed up by scientific investigation. There is scope for much more development of this approach.

component parts. Studying what these parts do in isolation is not useful. Complex systems behave in a way that is determined by how the different components are interconnected and by the interactions between them. So by disregarding the effect of the interactions, one loses any chance of actually understanding how the system works and how it will respond to external interventions. It is not feasible to do experiments on the entire health system to test the effect of different large scale interventions, say: such an experiment would be too costly, too dangerous or wholly impracticable. Nor until very recently, was there any way of studying these sorts of systems as complete structures. The emergence of computer power, especially that based on massively parallel processors, has changed this situation by allowing the possibility of more realistic modelling of such systems. With such a model, simulations can be carried out that are equivalent to experimentation in a laboratory.

Examples of models that have been developed in other sectors are: the Stock Market; and city-wide road traffic systems. While of impressively large scale these are, however, essentially of a

mathematical kind and need to be developed to handle “knowledge” as well as data to meet at least some of the needs of global health research. There is scope for major effort on modelling and simulation in the global health context.

One important task for modelling is to help objectively identify non-health sector influences on health status and the pathways by which they act. If it were possible to “model” these pathways as a “system”, strategies for intervening could be identified. Interventions in systems like this cannot necessarily be treated as simple inputs to nodes or as modifications of pathways. A successful intervention would not only generate the intended result, but is likely to have ongoing additional consequences that must be taken into account. It would be difficult to forecast such consequences, and impossible to identify their scope and severity, without a realistic model of the system. Developing such a model would face a special difficulty because it probably could not take one of the many varied forms conventionally used in different scientific

disciplines. Thus if the model had to use “knowledge-based” indicators - as would seem likely - it would need to comprise at least some aspects that are very different from conventional models, and research is needed in this area also.

“Behavioural” models of systems, such as health care delivery systems are another important area. Successful developments here would help in designing more effective organisations, adding an extra dimension to the analysis and design processes, at both large and small scale. Even the architectural layout of hospitals has a bearing on how effectively staff interact in carrying out their tasks and, more important, how they react to overloading and to emergencies.

Substantial methodological developments are required in order to provide the means for studying the complex but doubtless important relationships influencing health. This is why early attention to this topic is important.

## 6.6 Priority setting methodology

As pointed out at the very beginning of this Research Policy Agenda (see Scope and Purpose, pages 1-2) there can be no simple, single meaning for the concept of “**priority**”. The question is, **priority for whom?** Every government, people and institution has its own notion of “priority” serving its own purposes, within its sense of mandate, capacity, culture and resources. The scientific community is motivated by the pursuit of intellectual opportunity, but it can be enticed to mobilize and direct its efforts and energies if it knows of the needs and priorities of others. The health needs of humanity are holistic and legion, and so are the research opportunities, as reflected in Chapters 5 and 6 of this Research Policy Agenda. The question presented here is whether there are new effective,

rational methodologies that can help different parties set priorities for health development research, and perhaps also lead in the direction of a better global consensus. It is clear that the “unfinished health agenda” is enormously complex, and the issues raised encompass very many detailed research problems, not all of which can or should be handled simultaneously with the same degree of effort and prospects of success. How should effort be distributed? How can priorities be set and updated? It is assumed that objective and efficient decision-making is required in this situation. The Research Policy Agenda proposes to put new methodologies at the service of a continuing dynamic process of priority setting.

### 6.6.1 Criteria for priority setting

An acceptable list of criteria for priority setting in health research still needs to be agreed. A few possibilities can be mentioned. One relevant criterion is “the scale and urgency of the need, based on health level assessment, and on an understanding of the fundamental causes of the health problem”. Others are “the likelihood of success in any research”, “the availability of human and other resources to do the work”, and “the likely time-scale”. Equally important are “the consequences in subsequent years of the possible interventions likely to follow from the research”, and “the existence of other options for intervention, outside the health sector”. Decision-making that neglected such factors would be potentially hazardous and generally unacceptable.

### 6.6.2 Constraints and resource allocation

There are at least three ways of using criteria. First, one could imagine a computer simulation of how these various criteria contribute to priorities. This approach may be marginally impracticable at the moment. Second, one could generalise the “constraint” concept. Each individual criterion could be transposed into a form that constitutes a “hard constraint” or a “soft constraint” that would limit decision options. A “hard” constraint is one that must not be breached; cultural factors sometimes constitute “hard” constraints. “Soft” constraints are those which are not absolutely forbidden but which are increasingly undesirable as they are increasingly breached. An example is “a short time scale for the research”; the longer the time-scale, the less acceptable on these grounds. Constraints may be expressed in quantitative terms (e.g., the cost limit is USD20 million), or in the form of specific statements (e.g., the necessary research staff should not exceed number N1 virologists, N2 biochemists, N3 molecular pharmacologists, N4 epidemiologists or .... as the case may be). Some constraints need to

Some of these criteria are non-numerical: they call for human expert judgement and would be described as “knowledge-based”. To take such criteria into account needs “knowledge-based” technology. At the same time, it is necessary to remember that in planning actions, whether of research or of interventions, one’s freedom to select appropriate and useful actions is frequently circumscribed by the existence of limitations of many kinds. Acceptability, cultural factors, costs, availability of human resources, practicability and such like, are all “constraints” on action. In judging the impact of criteria therefore, it is necessary to bear in mind the constraint issue, because the constraints may dominate the task.

be expressed in so-called “fuzzy measures”. “Likely solutions must be implemented easily” is one example; “the likelihood of success should be fair, good or very good”, is another. Other constraints arise in the context of resource allocation because of limitations to implementation. These examples make clear that different research problems would experience different constraints, or at least differently categorised constraints.

**Constraint logic programming** is a “knowledge-based” technology that uses a further development of logic programming. The strategy of constraint logic programming is to search automatically through many solutions, using the existence and the nature of the constraints to discard those classes of solutions that are unacceptable, and ranking those that are influenced by soft constraints. (Solutions, in this context, are acceptable options for the distribution of priorities.) Part of the skill of the technology of constraint programming is to analyze and use the logical structure of the constraints

automatically to make the task of identifying unacceptable solutions into a highly efficient process. Some development work would be required before constraint logic programming can be transposed for the needs of global health.

A third research option exists for the resource allocation problem. This is to construct a special kind of model - "knowledge map" - that assesses the impact of various criteria, taking into account how they combine and interact, and to what effect, then applying each option individually to determine their level of overall "performance". The high level output from this "knowledge map" is not only how each possibility for action "scores" in terms of the individual criteria, but the inferences about how, collectively, they constrain action.

Applications in health situation analysis also exist for the "knowledge map" methodology, focussing on the fact that health status has both a positive and a negative aspect. Health deficits are those components which should be the first to receive attention, although health deficits need to be interpreted in the light of positive health components. A "knowledge map" of health deficits

could be built up from the constraints, and handled by logic programming and by constraint logic programming. If it can be achieved, this would allow, inter alia, trial experimentation of the effects of intervention strategies. In fact, it would only point to the consequences for health deficits of the interventions proposed; apparently desirable actions would need to be further considered in respect of their impact on the initially positive aspects of health status. So a "map" of the positive health aspects would then be required.

The same kind of approach could perhaps be used for studying intersectoral effects, because the output of the "map" would also "point" to non-health sector linkages. It is suggested that this could be a generic technology, since the "map" concept can be applied to other sectors.

Technologies based on constraint logic programming are now coming into use for industrial purposes where best possible use of resources is vital. It seems appropriate to envisage their use in the global health research arena, where the problems are more far-reaching and the available resources relatively more constrained.



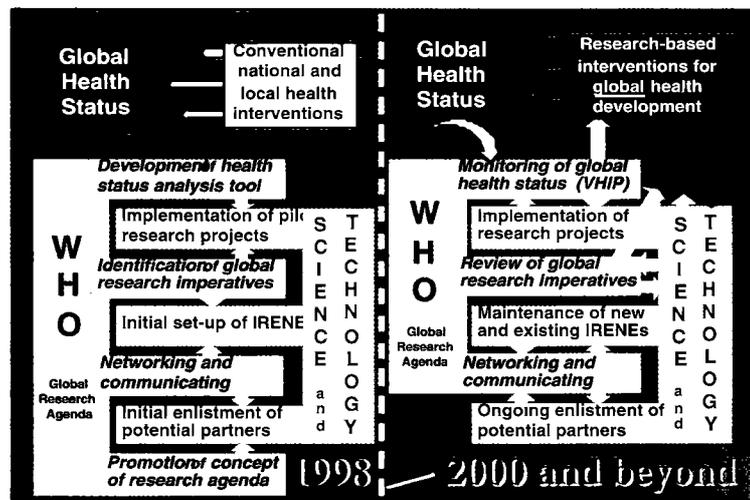
# 7 Implementation of the research agenda system

- ◆ Strategic concept and design
- ◆ Operationalization

## 7.1 Strategic Concept and Design

In order to mobilize the entire scientific community and partners to implement a Research Policy Agenda in support of global health development, it is proposed to initiate and sustain a systematic, dynamic process of dialogue, joint planning and multidisciplinary participation in research, making fullest use of modern information and communication technologies, and acting through a global network of “intelligent” research networks that address the major research imperatives and opportunities in all domains affecting human health. The strategic concept for implementing the Research Policy Agenda, including “feedback loops” in the self-sustaining process, is schematically represented in **Figure 8**.

It consists of the Planning Network for Health Research (Planet HERES) and the Intelligent Research Networks (IRENEs), both based on Information and Communication Technologies (ICT).



**Figure 8: Strategic concept for implementing the Research Agenda**

Implementation of the Research Agenda will require a clear strategy. This figure shows how the key components of the research planning and evaluation process fit together and how their relative weight changes from an initial phase to a self-sustaining process.

This process is based on a detailed analysis of health status and the recognition of deficits, the identification of imperatives and opportunities for global health research, and the transfer of this knowledge to programs which aim to reduce the health deficits. Monitoring the effects on health status of measures implemented as a result of the research closes the feedback loop. A new cycle begins with a new description of the health status. The Planet HERES approach integrates strategic research planning techniques and telematics to facilitate this process.

### 7.1.1 Planning Network for Health Research (Planet HERES)

At the centre of the research planning system, it is desirable to have an “intelligent” entity acting as the “engine”, “catalyst” and “custodian” to help coordinate and inspire system development, to carry out research planning tasks on behalf of the network of partners, and to hold or facilitate ready access to new knowledge, methodologies and results of scientific research - in short, a planning network for health research. The planning network will help the scientific community and other partners in health development to carry out specific research planning tasks, including:

- Analyses of current world health and development conditions and problems - the “status quo” versus what is desirable and achievable - the health “gap”;
- Identification of what is known and not known - the “knowl-edge deficits” facing problem resolution including barriers to use of existing knowledge;
- Development of new knowledge, methodologies and approaches that contribute to problem solving and ultimately to better health.

The network will also help the scientific community and partners ensure successful “outcomes” and “products”, notably in the form of:

- Research and development (R&D) results;
- Research capacity building; and
- Life-long competencies and creativity.

A visual presentation of this continuing and dynamic process is contained in **Figure 9**.

It is in line with the Constitution of the World Health Organization to propose that WHO would

assume the responsibility to establish and serve as “custodian” for the global planning network for health research. Through its Advisory Committee on Health Research, WHO is already taking initial steps in this direction.

“Planet HERES” (Planning Network for Health Research)<sup>5</sup> has been established to initiate work on research planning processes and networks, and to reach its design goal of improving such processes by (see also Annex C):

- enabling computer-supported discourse among members of a health research community;
- improving the utilization of existing knowledge and providing access to various types of knowledge resources, (e.g., data bases), through information broker technology; and
- strengthening individual research capacity and empowering individual researchers with knowledge assessment and compilation through individual workspaces.

The “Planet HERES” approach is designed to facilitate the use of telematics as the enabling technology for globe-spanning, regional and national research planning processes. Telematics services support a synchronous and asynchronous exchange of multimedia information, such as printed text, figures, graphics, videos and other means of illustration.

“Planet HERES” has already begun to undertake work designed to illustrate the implications of the present global development trends and to provide the ACHR-System with a support system by which to evaluate possible (health) effects of various political, social, environmental, and economic measures, and to elucidate areas in which more

<sup>5</sup>For further details, see: C. Greiner, I.T. Hawryszkiewicz, T. Rose, T.M. Flicdner: “Supporting Health Research Strategy Planning Processes of WHO with Information Technology”, in K. Sandkuhl, H. Weber (Ed.), ISST-Report, *Telecooperation Systems in Decentralized Organizations*, pp. 121-145, Berlin, Germany, 1996 ISSN 0943-1624.

research is needed. This includes the evaluation and validation of knowledge and knowledge transfer deficits, which could lead to a priority list for health research. To facilitate visualization and analysis, a “Health Profile” has been developed (see Annex B). This approach will enable health research priority setting activities to be described and documented in terms of transparent processes. This includes time schedules, participant and contributor lists, time tables for review and endorsements. It is envisaged

that the outcome of “Planet HERES” will promote on-going operational health research planning and networking capable of generating a global consensus among participating scientists in defining health related research priorities for WHO. “Planet HERES” will also serve as an “intelligent search engine” platform or catalyst to help put together existing and new forms of research institution networks, linking “North-South”, “East-West” and “South-South”, as described further below.

### 7.1.2 Intelligent Research Networks (IRENEs)

As a central component of the Research Policy Agenda, it is proposed to develop a worldwide “intelligence” network - “intelligent” in the sense of dealing with knowledge and experience in a rational, informed and intelligible manner - by enlisting existing institutions and networks, and designing new and more effective networks and partnerships, using modern information and communication technologies. For convenience, and not for any “proprietary” purpose, these new-type or augmented networks are referred to as “**IRENEs**”, for “Intelligent Research Networks”. An Intelligent Research Network (IRENE) can be described in the following way:

An IRENE is an international network of research institutions and partners designed to address a significant global health problem which is amenable to solution or improvement through a cooperative research approach, contributing to the attainment of

#### **An IRENE is a research network that is:**

- ◆ Issue-oriented for HFA
- ◆ Internationally cooperative
- ◆ Interdisciplinary in approach
- ◆ Inter-domain in research coverage
- ◆ Informatics and telematics-based

#### **Examples of IRENE research issues contributing to HFA:**

- ◆ New approaches to food production, security and distribution
- ◆ Health impacts of population growth, structural change and migration
- ◆ Determinants of unhealthy anti-social behavior including violence
- ◆ Combined health effects of multiple toxic exposures in the environment
- ◆ Global tracking of microbial resistance to drugs
- ◆ Research for industrial-scale production of a new vaccine for Japanese encephalitis
- ◆ Synergistic effects of stress factors on health in the workplace and in the home
- ◆ Development and application of methodologies for health measurement and knowledge-based assessment of health

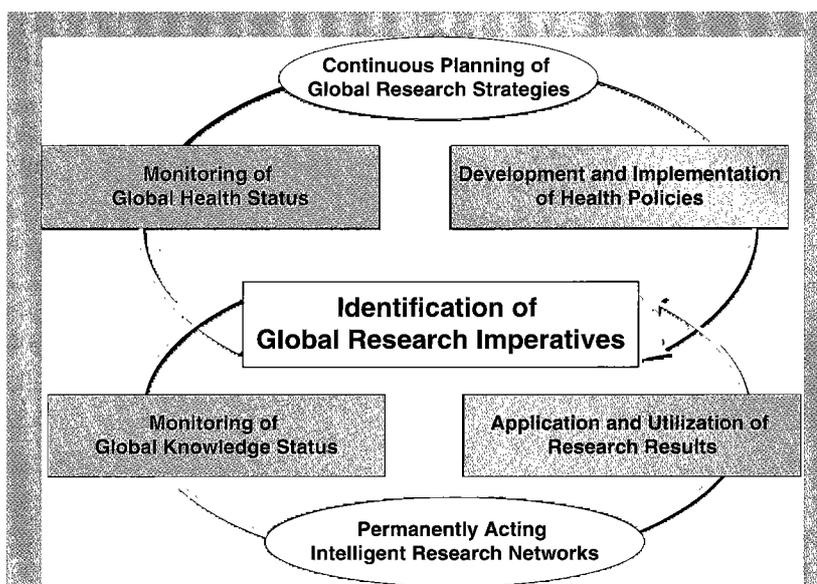
Health for All. An IRENE is “intelligent” because it maximizes the creativity of a group in the application of scientific method, knowledge and technology to solve specific problems. The effective use of modern informatics and telematics is a central feature of an IRENE. An IRENE is usually

interdisciplinary in approach, and inter-domain with regard to research coverage. The “I” in IRENE is also intended to imply several other definitional criteria (see previous Boxes).

The global research network will itself be composed of a series of IRENE networks built around common themes and purposes, and dealing with such critical issues as population, urbanization, food and water, environment, microbial threats, health systems and education, as described in Chapters 3 and 5 above. Furthermore, by linking scientists, research institutions, educational institutions and other partners, IRENEs will contribute to individual and institutional research capacity strengthening. To organize these networks, it will be necessary to form consortia of the most competent interested and involved scientific institutions, donors and other partners, as indicated further below. To ensure the global and regional coherence and development of the overall system, it will be necessary to identify among the many participants a few of those institutions that are willing to carry out responsibilities as regional „hubs“ serving the global network. They will foster collaboration, facilitate information access and exchange, and carry out monitoring and evaluation duties. A small but definite portion of the resources mobilized for research activities of the network participants will need to be made available for „overhead“ support costs of the regional „hub“ institutions carrying out these systems maintenance function. Conceptually and organizationally, therefore, the network is global, but it is composed of purpose-oriented

consortia and networks, and it is supported by regional „hubs“ to ensure coherence of the overall network system. The concept of Intelligent Research Network is illustrated in **Figure 10**.

The global research network will not require the establishment of any large, new institution, with all the expenses which that would entail. The network will be based mainly on WHO and other existing partners, with modest institutional strengthening for those carrying out particular network responsibilities. Nor does the global network envisage central dictation or determination of what research activities different institutions must undertake,



**Figure 9: Dynamic processes involved in identifying health research imperatives**

Identifying global research imperatives will require two separate ongoing activities: continuous systems planning will monitor the global health situation and identify research opportunities; permanently acting scientific communities will monitor the state of the art of existing knowledge, establish how this can be used, and identify where new knowledge is needed, leading to new research initiatives. These scientific communities will be linked and supported by means of information and communication technologies in so-called Intelligent Research Networks (IRENEs).

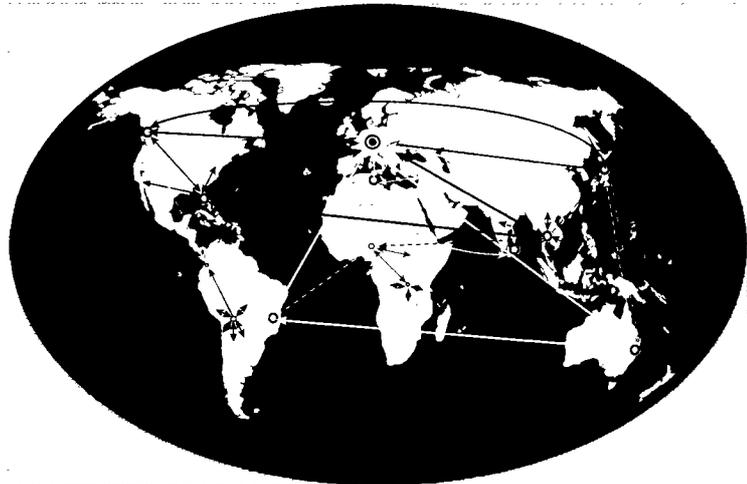
although it is expected that sponsored research will contribute toward internationally defined health development objectives and health deficit or problem solution. The assignment or sharing of research activity responsibilities will result from

communication within the web. Thanks to modern communication and informatics technology, discussed further below, the management of the system and its data bases will remain essentially decentralized.

### 7.1.3 Information and communication technologies (ICT)

Both the Planning Network for Health Research (Planet HERES) and the Intelligent Research Networks (IRENEs) described above will make optimal use of the available and evolving information and communication technologies (for convenience referred to here as "ICT"). The methodological focus of these efforts is on computer supported cooperative work and a renewed emphasis on multidisciplinary and transnational scientific and technical cooperation.

The advent of advanced ICT and the new Internet telecommunications system continue to have a dramatic impact on the research process itself: literature searches, collecting relevant articles and data, discussions with other researchers, writing papers, peer review and journal publication are often carried out electronically from a researcher's office. Information technology has presented a new way of conducting research and opened up the possibility of allowing many other scholars and students to observe and even participate in the process. A negative corollary, however, is that those without access to the information highway find



**Figure 10: The Concept of Intelligent Research Networks (IRENEs)**

To harness and involve the available power of the scientific community it is necessary to establish entirely new forms of "networking" between research institutions in "North and South" and "East and West" but also between the different scientific disciplines. Networking will utilise and exploit the full possibilities and potential of modern information and communication technologies to address the identified problem areas by research and development actions.

What is proposed in the Research Agenda is the development of world-wide „intelligence“ networks, with certain institutions willing to carry out responsibilities as regional „hubs“ to foster information access and exchange. IRENEs are designed and built around substantive and/or methodological issues of strategic interest to health development, and they open avenues to participation by all interested parties.

themselves increasingly marginalised from the academic and research mainstream. Specific efforts must be made to ensure the inclusiveness of the system.

Mobile and robust computer hardware in combination with connectivity software and access to wireless and fiber-optic cable networks promise to have a dramatic impact on research of all kinds. The implications for global research capacity, flexibility and productivity are significant. As

inequities are easily created by such advances in science and technology, deciding how and where to allocate resources to the new research imperatives and opportunities may be difficult. Development of ICT hardware and infrastructure for developing countries will need to be directed toward robust, cheap and readily maintained systems. It will be necessary to ensure sufficient compatibility and equitable access to the benefits of ICT among all partners in the international network.

## 7.2 Operationalization

- ◆ Concepts for implementing the system
- ◆ Organizational and fiscal requirements
- ◆ Requirements for review and quality control
- ◆ Enlisting partnership support
- ◆ Partner responsibilities

### 7.2.1 Concepts for implementing the system

The establishment and effective operation of international networks of scientific research institutions for health development requires a common cause and commitment to overcome barriers to implementation: lack of political will, election expediency, unavailability of sustained funding, vested interest, lack of communication, lack of a minimum set of ethical values, lack of cooperative initiatives, lack of global consensus, unfair market conditions, rapid global transitions and change, lack of validated information, ineffective use of existing knowledge, educational and language barriers, global variability in resources, capabilities and expectations, as well as other cross-cultural differences.

The key to overcoming the barriers to implementation and making progress to influence

health development, can be summarized by the following ten letter “C” concepts:

- Competence of the partners, in terms of mandate, expertise and capacity;
- Creativity and imagination to see and construct new solutions to new and old challenges;
- Confidence in the partnership, the means and purpose of the common enterprise;
- Commitment to the common cause and the role of science in human development;
- Courage to exceed disciplinary limitations in favor of transdisciplinarity;

- Consensus on the main objectives, policies, approaches, ethical values and purposes of the initiative;
- Cell or “Club stage” of founding partners as necessary to initiate the network process (see below);
- Continuity, to ensure its continuation, expansion, funding and product outcome;
- Cooperation among the partners, which is the essence of what the international research network is all about;
- Capacity building to ensure full and equitable participation in research;
- Continuous monitoring and evaluation of the Research Policy Agenda, and the quality and applicability of research results.

### 7.2.2. Organizational and fiscal requirements

The creation of such a program, a globe-spanning network of scientific institutions and other partners to carry out a Global Research Policy Agenda for health development, cannot be realized in a single stage. Rather it may be necessary to start with a smaller cell or “club stage” of founding partners to initiate an IRENE network process, drawing mainly on existing institutions and the WHO network of collaborating centres and regional offices supported by some “seed money” financing. A few of these institutions may be willing to act as experimental stations to test and develop systems and technology, and to interact with local or regional institutions, and thus gradually build up the global network. This will require experimental work on: management techniques; data collection, analysis, storage and retrieval; interactive communication systems; research opportunity identification; sharing of research inputs, activities and outcomes; and monitoring and evaluation of research activities and processes. The idea is to test on an incremental scale and gradually build towards a truly global network that embraces the entire scientific community and other partners whose work and interests are aligned on world health development.

The global research network does not require any major organizational creation or generation of major

additional resources beyond the resources and energies which the partners bring to the common enterprise. The targeted initiative does imply some reallocation of existing resources, and the application of some specific catalytic and “seed money” to launch the system and initiate some critical research. The future sustainability of the system is dependent on cost economy and affordability.

The operation of the global system is premised on the idea that each participating institution or person gives what he can - knowledge, information, manpower, money or contributions in kind. All partners share their inputs, data and research results. Some catalytic money is needed to launch the initiative, particularly to help pay for responsibilities accepted by regional “hub” institutions described, above. Finally, some “seed money” will be needed to initiate specific research activities, especially in the developing countries and smaller, less-endowed institutions which can nevertheless make important research contributions to the common purpose. Sources for such funding may include international organizations, national governments, national and regional authorities and unions, foundations, private sector industry and other contributors who have an interest in the outcome of the targeted research.

### 7.2.3 Requirements for review and quality control

**Standardisation and compatibility:** As in any complex decentralized system, effectiveness and efficiency of the global research network will depend on a reasonable consensus on policies, methodological approaches and standards, and on compatibility of communication systems, information technology and data bases. A number of internationally accepted standards, such as WHO's International Classification of Diseases (ICD), already exist and can be readily used for data collection, analysis, processing and storage

purposes. Other standards will have to be developed or adapted for networking purposes. Information relevant to health situation and deficit analysis, identification of critical issues and research opportunities, means of cooperation and financing, as well as methods of monitoring and evaluation, must be readily communicable among institutions in the global network, and capable of processing by compatible informatics systems. Methodological approaches requiring standardization and compatibility are also discussed in Chapter 6 above.

### 7.2.4 Enlisting partnership support

In addition to the active participation of individual scientists and scientific institutions, bringing their respective intellectual capabilities, creativities and resource potentialities, other partners must be brought into resonance with the initiation of a new phase of global health research. Of particular importance, as an integral part of the scientific community, are the professional international scientific societies and unions, such as CIOMS, ICSU, INCLIN. They need to be encouraged to act as the "scientific umbrella" as well as catalysts for the envisaged scientific and technical activities. During the last four decades, WHO has designated a large number of WHO Collaborating Centres. Many of them are already engaged actively in research relevant to the renewed Health for All Strategy. This existing infrastructure will need to be expanded and recruited to contribute in new ways using new technologies, including advanced communication technologies, to link up and become members of new types of problem-oriented "intelligent" research networks.

It is necessary to enlist the support of the essential policy-makers, including national governments, regional political unions, United Nations Organizations, the European Union, and the South

East Asian Economic Community. These bodies would have to explicitly provide the political and legal base of the envisaged activities and take not only note of, but support the new global dimension of collaborative activities between North and South as well as East and West. In addition, active and strong support is needed by the research funding agencies and sponsors (research councils, foundations, industry). At the present time, estimates indicate that research relevant to health research attracts more than 50 billions of dollars of which approximately half come from industry and the rest from governmental sources, and from foundations. Collaboration and support is required from educators and opinion leaders, end users, health professions, community leaders, media, teachers, parents and others. It is particularly important to ensure from the very beginning, that a "global research dialogue" is established especially between the industrialized, the industrializing and the developing countries. The scientific community and its productivity is unevenly distributed throughout the world. It is estimated that more than 90% of the scientific publications of the world are derived from research institutions of some 20 member countries of the UN system. This implies that the wealth of intellectual brain power to contribute to science and technology

in support of the global health development is underutilised. The networking design of the Research Policy Agenda is intended to rectify this situation by drawing on the brain power available in all countries of the world.

### 7.2.5 Partner responsibilities

#### Responsibility of WHO

After reviewing the report of the Advisory Committee on Health Research on “Science and Technology for Global Health Development” and recognizing its relation to the Strategy for Health for All, it would be for the Director-General to decide to submit the proposed Research Policy Agenda to the WHO Executive Board for consideration and transmission to the World Health Assembly. WHO would then inform all WHO collaborating centres, sister agencies in the United Nations’ system, as well as relevant Non-governmental Organization and other institutions in official or working relations with WHO, encouraging them to address critical R&D issues on the Research Policy Agenda in their own program of activities and report thereon in their regular meetings and in their communications with WHO. WHO will make an extensive use of its expert

committees, which constitute a bridge between the Organization and the scientific community. In addition, WHO will review relations with all their WHO collaborating centres, and identify those that will become active affiliates in the global research initiative, including those that are prepared to act as regional “hubs” in the global institutional network. WHO will provide opportunities to form and run international research networks, involving consortia of scientific institutions, contributors and other partners. WHO will help initiate, develop, monitor and evaluate the Research Policy Agenda, including the IRENE process. The role of WHO should be to facilitate the IRENE process, not to “own” it. The ACHR will continue to support the Director-General in doing this.

#### Responsibility of governments

Member States at the World Health Assembly will be invited to consider and endorse the global Research Policy Agenda as a complementing and supporting initiative for fulfilment of the Strategy for Health for All. Governments would take the global Agenda fully into account when developing their own national policies, strategies and programs for health and human development, and when participating in authoritative regional bodies, unions and organizations. All relevant national authorities should be fully involved, including Ministries of Foreign Affairs, Development, Health, Education,

Agriculture, Science and Technology, Finance and Economic Affairs. Governments have a role to play in mobilizing and encouraging their own institutions, including scientific research institutes, universities and academies of science, to engage themselves in the Research Policy Agenda and network. Through appropriate governmental decision, these institutions would be authorized to use a portion of available resources for this type of global cooperation. Provision should be made for “seed money” to initiate the research component of their programs. Governments should support the strengthening of

national research institutions, encourage scientific manpower development and promote capacity to deal with essential national research issues and contribute to the Research Policy Agenda.

### **Responsibility of the scientific community**

This initiative is dependent on the collaboration of individual scientists within the international scientific community. The entire scientific community, including national and international research institutes, universities, academies of science and others, should be duly informed about the scope and purpose of the Research Policy Agenda. Interested institutions and individuals would be invited to become active participants in the IRENE process, and to take part as appropriate in specific research opportunities identified through the targeted research initiative of the Research Policy Agenda. The scientific community will make use of all means of modern communications and information management for the exchange of information, including use of electronic means for continuous updating of specific research opportunities. Appropriate international bodies dealing with science and technology (e.g. CIOMS, ICSU, IAE

Governments will be kept informed of the results of monitoring and evaluation of the Research Policy Agenda.

and academies of science and technical engineering) will be asked to consider the Research Policy Agenda at their governing body meetings, and should exchange information on specific research opportunities. Certain of these bodies may be enlisted to serve as agents for a Research Policy Agenda promotion. The scientific community is well-positioned to provide the necessary training, using advanced telecommunication technology, to develop appropriate scientific manpower to work in the international research networks. The scientific community will need to continuously monitor and evaluate Research Policy Agenda developments. It would be hoped that international scientific bodies will provide time in their regular meeting agendas for review of results obtained from interdisciplinary research and discussion of potential impact for global health development.

### **Responsibility of foundations and other partners**

A variety of enabling partners, including foundations, contributing agencies, non-governmental agencies, associations and others, need to be brought into the global network, not only because they can contribute financially, but also because they have an interest in the research outcomes that contribute to global health development. They are also “co-owners” and have a “stake” in the international research system. These foundations and others must be fully informed about the targeted research initiative, and enabled to provide perspectives relevant to the Research Policy Agenda. Their help can be solicited in publicizing the Research Policy Agenda, and

promoting understanding of the Agenda as a mosaic of worthwhile opportunities to invest in research activities that contribute in a coherent manner to priority health problem solutions. Foundations, contributing agencies, associations and others will be invited, as appropriate, to participate directly in the consortia and network of special interest to them and to provide catalytic financial support to specific research activities and institutions, on the understanding also that reasonable provision can be made to help defray the “overhead” cost of the supporting system. These institutions will receive reports on financial accountability and will be kept informed of results of program evaluation.

### **Responsibility of the private sector**

Many industries, commercial enterprises and other private sector institutions have an interest in the Research Policy Agenda because they are important sources and contributions as well as users and beneficiaries of new technologies, leading to new and better products and market opportunities. Appropriate access to the global network and exchange of information on the Research Policy Agenda can be granted in respect of research

endeavours of a non-proprietary nature. The proper balance has to be struck between commercial interest and public health and development concerns. Thus attention must be paid to ensure that patents are applied in ways that encourage access to health technology and protect and promote health development. The effect of targeted research will in many cases increase overall market size while contributing to better health for all.



## 8 Conclusions and recommendations

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The report of the Advisory Committee on Health Research on “A Research Policy Agenda for Science and Technology to support Global Health Development” stresses the urgency of research on continuing and emerging problems affecting the health and well-being of all the world’s populations.

The report emphasizes the crucial role that all fields of science and technology can play in the light of significant advances in the past and opportunities for the future, in the realization of the global policy and strategy of health development in the Twenty-first century.

The Research Policy Agenda outlines the main domains of global health development, and provides an initial, non-prescriptive description of research imperatives and opportunities, including methodological needs.

The Research Policy Agenda proposes a strategic concept and design of a dynamic research planning system, which includes of a Planning Network for Health Research and Intelligent Research Networks, making optimal use of the available and evolving information and communication technologies.

The role of WHO is seen as “facilitator” of a process that belongs to all, including governments, the scientific committee, foundations, the private sector and other partners.

**Action required.** What is now required is the political will and commitment of the entire health and scientific community and all relevant partners, attuned to the concept of the Research Policy Agenda, and to begin the collaboration necessary for its further development and implementation.

To this end, the WHO Advisory Committee on Health Research will continue to support the initiatives described in this report.

The role of WHO is vital to the success of the endeavour, in the sense of “facilitating” an international cooperative process that belongs to all.

Member States may wish to collaborate in and support these efforts to bring the full potential of all branches of scientific research to bear on global health development.

All States, with their scientific institutions and related partners, would be kept fully informed, individually, and collectively through their membership in the World Health Assembly, of development and implementation of the Research Policy Agenda, and their participation and support would be sought, in furtherance of the goal of Health for All.



# Appendix

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# Annex B

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## Representing and analyzing multi-dimensional aspects of health development: The Visual Health Information Profile (VHIP)

### Abstract:

A new approach for illustrating and analyzing the health status of a given population is presented. The approach takes the multi-dimensional nature of health into account. It is based on a flexible hierarchy of health indicators, a decile reference system and a computerized information system.

The instrument displays the health status of populations visually and allows comparisons to be made of various health parameters during different time periods. The instrument also permits health comparisons of different populations during selected time periods. Using this approach, it is possible to represent quantitative as well as qualitative aspects of health, to monitor the impact of health interventions, and to assess the extent to which objectives in the health field have been achieved. Therefore, this instrument can promote communication between policy makers and scientists and can assist individuals as well as governmental agencies in the management and coordination of programs which are designed to support health development.

The approach has been tested on several populations by using the official data bases of the World Health Organization (WHO), the World Bank, and the United Nations Development Programme as the main data sources. Country and region specific health status patterns were generated showing the practicability of the approach.

### 1 Introduction

The mission of the World Health Organization (WHO) is to improve human health throughout the world. To accomplish this goal, health targets must be specified, health research activities initiated, and health programs implemented accordingly, to overcome detriments which impede the „Health for All“ strategy. Therefore, it is necessary to describe accurately the health conditions prevailing throughout the many populations of the world first.

The assessment of the health status within a given population, however, involves the evaluation of

complex interrelationships of various causal and contributing factors to human health development [6,10]. The World Health Organization, through its Global Advisory Committee on Health Research (ACHR), initiated steps for the expressed purpose of developing new approaches to overcome these difficulties [32].

Based on this initiative, an instrument called the „Visual Health Information Profile“ (VHIP) was developed [1,2]. The VHIP concept provides a quantitative description and assessment of the multi-

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dimensional aspects of health for a given population and makes it possible to examine the potential interrelationships of the multiple parameters of health. It can be used to identify health deficits and major areas of poor health and to monitor improvements or decline in the health status over time. In principle, it can be applied to the individual, the family, the community, the region and to the world as a whole, if appropriate data are available. By implementing a supporting information system, a high degree of transparency and flexibility with respect to the input data and the choices of measurables was achieved.

## 2 Conceptual requirements

The objective of the ACHR activity was to develop an instrument which could describe and display in quantitative as well as in qualitative terms the multiple determinants of health. As this instrument is to be used as a decision support tool in the field of health policy planning the following conceptual requirements were defined:

- The multidimensional nature of health must be reflected.
- A global comparison of different health related measurables and different populations should be possible using a common reference system for different sets of data.
- Areas of poor health should be able to be assessed quantitatively.

## 3 The indicator system

A hierarchy of indicators was developed in which the key-aspects of 'health' are grouped into five categories called 'health domains' (1st level). Different elements within each health domain are represented by various measurables in a 2nd level, or the 'health component' level. Each component can be supplemented by other critical health

The VHIP instrument was applied and tested as part of a research project called „Planning Network for Health Research“ (Planet HERES), which provides support for the overall research planning process within WHO [13]. For the future, the Visual Health Information Profile (VHIP) is intended to be used as a communication tool by governmental agencies, by the scientific community, by practicing health professionals and by the other partners in the health planning sector.

- A selection of relevant measurables should be able to be visualized in a single graphical display.
- An information system should be provided that allows the analysis of input data in a user-friendly environment.

Since there is currently no instrument available which can integrate such a broad spectrum of health parameters in analyzing the health status of populations, the proposed new approach (VHIP) represents an important first step towards this end. Implementation of this approach by using currently available global data has already yielded promising results.

indicators and measurables at a 3rd level, or the 'sub-component' level [11,12].

The VHIP is based on the following five health domains which cover the important factors of a population's health status (see also **Figure B.1**): **Disease Conditions and Health Impairments**,

### Health (Care) System, Socio-Cultural Characteristics, Environmental Determinants, Food and Nutrition.

Although many indicators designed for assessing different aspects of health development are in use, there is no consensus on which indicators are most suitable and reliable to describe the health situation of a population [35]. Being also aware of the difficulties and inherent limitations of health related indicators, the following criteria for selecting an indicator for the VHIP approach were defined [4,16,17,18]:

- the indicator has to have a significance to the entire concept,
- the indicator should be clearly defined and comprehensible,
- the indicator should be robust enough to reveal trends over time in health development,
- data for an indicator should be available for as many as countries or populations as possible, and

- data should be collected routinely and by standardized methods.

In implementing the presented concept not all of the above stated criteria could be met for each indicator entirely. However, in order to be able to develop a first prototype of the VHIP, this list of criteria served as a guiding framework.

All measurables used in the system can be disaggregated when appropriate data are available. These include parameters such as “residency” (urban / periurban / rural), “gender” (male / female), “age groups”, etc. Thus, it is possible to trace back an observed value to its origin and to the actual problem level. This contributes to a high degree of clarity (transparency) in the use of this approach.

Due to the underlying information system, a health domain breakdown (e.g. the one of **Figure B. 1**), can easily be rearranged, changed or supplemented as appropriate in order to match a specified purpose, problem or goal (see chapter 8).

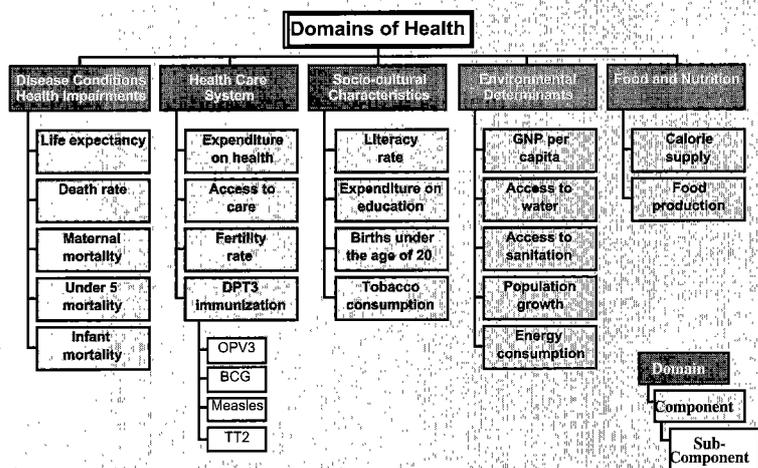
## 4 The Reference System

One of the goals of this research initiative was to illustrate a large number of health related data in a single and comprehensive graphical display. Therefore, it was necessary to develop a simple, objective and standardized methodology which allows the illustration of many indicators which are based on different units, range, and magnitude. A decile reference approach with a corresponding 10-point scale was chosen.

All globally available country-specific data for selected indicators (e.g. infant mortality rate) are ranked in order from the most desirable to the least desirable condition and are then grouped into deciles. The countries with the most desirable values for the specific indicator are placed into the 1st decile. Countries with the least desirable values are placed into the 10<sup>th</sup> decile. The first decile countries are then

assigned 10 points, the second decile countries are assigned 9 points, and so on. Thus, a relative rank-order for the selected health indicator is obtained and the original statistical value for a health indicator is compared to the values of all of the other countries for which the selected health indicator data are available (see annex for absolute and relative data). **Figure B.2** illustrates the procedure for converting absolute data into relative values using the decile approach [15].

The task of defining what is “most desirable “ and what is “least desirable “ will be subject to cultural, social, and ethical considerations. WHO’s objectives of the Health for All strategy were used as the guiding framework in this project. For example, a very low infant mortality rate received a “10” and a high infant mortality rate received a “1”. In the case of adult literacy, however, a high rate received a numerically high



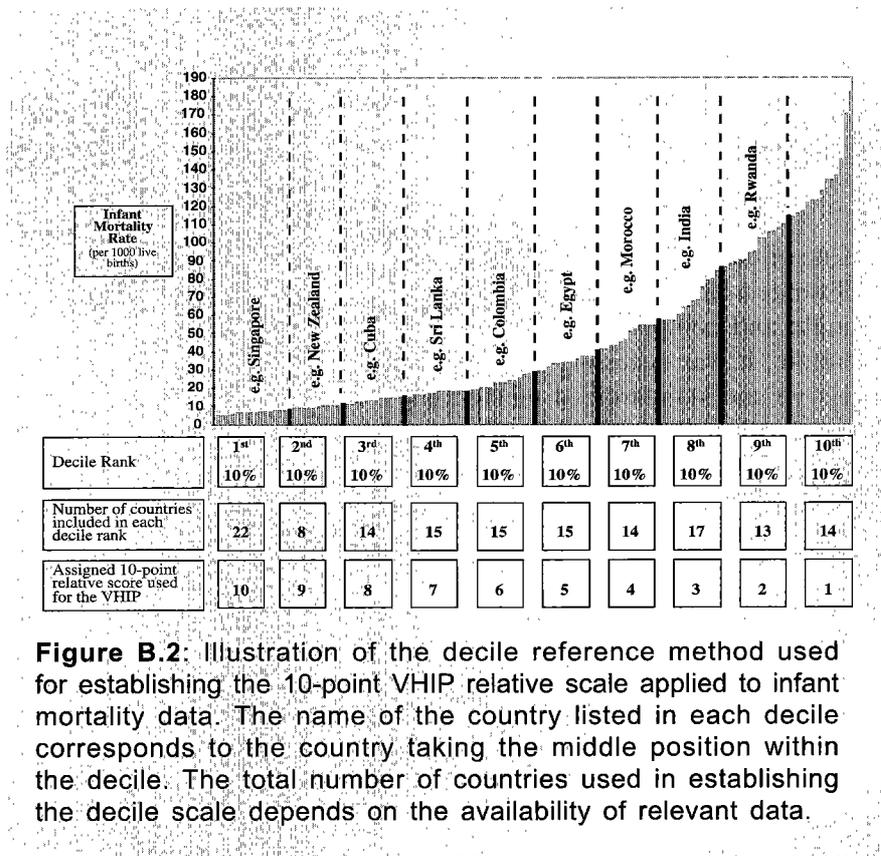
**Figure B.1:** An example of a breakdown of health domains into components. A detailed view of a further breakdown into sub-components is only given for the immunization component.

because data are not available at all, or are not as objective as they should be, it may be necessary to obtain information from some other source, i.e., from experts who are familiar with the conditions of a country. An expert may be able to transform his personal assessment of existing conditions into numerical values with respect to a health parameter or a specific health indicator. This value can then be used in the system because the reference system is based on a standardized scale. Thus, the decile based 10-point-relative-scale allows the representation of quantitative, or “hard” data, as well as estimates made by experts.

relative score (good) while a low literacy rate received a numerically low relative score (poor) [26,31].

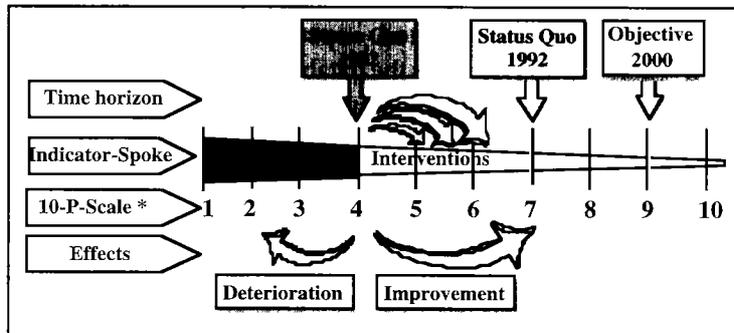
The values for the decile limits are calculated once for a specific year and remain fixed. Thus, they can be used for future reference when ranking indicator values of other years. This allows the visual display of improvements or deteriorations in health development for specific populations. However, the point value of a selected indicator for a given year should only be interpreted as a numerical value. One should not draw conclusions with respect to a decile position in another than the referenced year.

As it may be difficult to obtain access to desired data, either



**Figure B.2:** Illustration of the decile reference method used for establishing the 10-point VHIP relative scale applied to infant mortality data. The name of the country listed in each decile corresponds to the country taking the middle position within the decile. The total number of countries used in establishing the decile scale depends on the availability of relevant data.

## 5 The Visual Health Information Profile



\* 1 is considered as the "least" desirable condition, 10 as the "most" desirable condition.

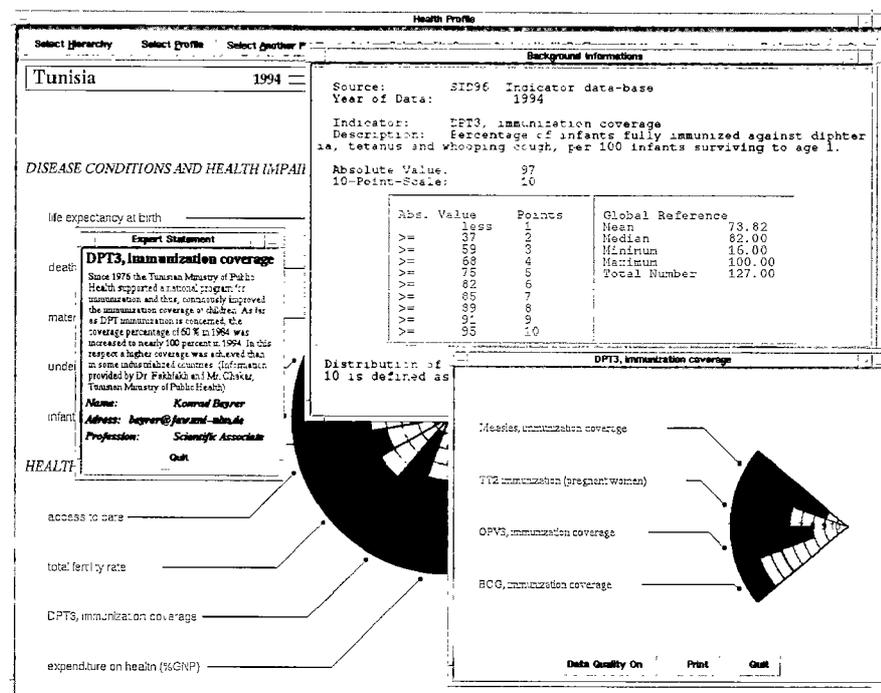
**Figure B.3:** Details of a sector representing a specific indicator

The VHIP has a circular shape with radial sectors<sup>1</sup> representing five health domains. In each sector, several smaller sectors represent the measurables according to the health domain breakdown. Each of these sectors is marked off linearly into a 1 to 10 scale such that the various measurables, can be "mapped" on the sector using the identical scale no matter what units are used or what range is included in the descriptors of the measurable. This allows the arrangement of different health indicators and domains in the same display. The scale values are arranged such that the minimum (i.e. a situation which needs urgent attention) is located in the periphery of the circle while the maximum (a very good situation) is located in the center of the circle. The scale value of an indicator always corresponds to the observed or measured condition and is displayed within its own sector (see **Figure B.3**).

When all of the values have been assigned to the

corresponding indicator spokes, a community or country-specific pattern of health measurables emerges (see **Figures B.5 to B.10**). Since the reference values of the 10-point-relative-scale are fixed, it becomes possible to compare a country's performance over time by evaluating the health profiles over several years.

From the view-point of its purpose, the VHIP is a comparative chart based on a vector-like display. It basically it is a representative of the major types of circular graphs and reflects characteristic features of a circular line graph, a circular area graph, and a sector graph. As VHIP is meant to reflect the health performance of a specific population at a specific time point it also shows features of a icon comparison display which is used to support the analysis of a sizable number of entities by pattern recognition mechanisms [14].



**Figure B.4:** Accessing the underlying database with all the relevant background information.

<sup>1</sup>A similar approach has been used for describing and graphically illustrating complex marine ecosystems [20]

## 6 Computer Based Information System

A structured database has been established which enables storage of all input data in combination with the health domain indicator breakdowns. A graphical user interface in X-Windows, based on Tcl/TK, was developed to create a user-friendly information system for investigating health problems within selected populations and to generate the VHIP profiles [8, 21]. Tracking back to more disaggregated data, as far as input data are available, is an important feature which adds a high degree of clarity and transparency of the entire approach (see **Figure B.4**).

The prototype version of the Visual Health Information Profile (VHIP) is implemented in the

language “C++”, a superset of C which incorporates object-oriented programming concepts. POSTGRES is the database used to manage the data sets, hierarchies, and results. The basic hardware platform is a SUN Sparc2 workstation.

A prototype version of the Visual Health Information Profile (VHIP) can be accessed via the Internet using the following WWW homepage address:

<http://faw.uni-ulm.de/planet/healthprofile/circle.html>.

## 7 Application of the Approach

The Visual Health Information Profile is able to illustrate the health status of a population using information based on statistical data published by international agencies including the World Health Organization, World Bank, United Nations Development Programme, and input in the form of estimates presented by international experts [22,23,27,28,29,30,33,34].

Due to a cooperative effort including the National Institute of Public Health in Tunis (Tunisia), the University of Peradeniya (Sri Lanka), the WHO Collaborating Center for Global Modeling of Health Perspectives at Schloss Reisenburg, and the University of Ulm (Germany), the health development in Tunisia and Sri Lanka is presented as an example of the use of the Visual Health Information Profile (see also [5,7,9]).

The 1966 health profile for Tunisia (see **Figure B.5**) can be considered a typical health profile of a developing country.

Poor conditions are documented in almost all health domains. Very low scores are seen for ‘access

to safe water’ and ‘access to adequate sanitation’, ‘GNP per capita’ and ‘food production per capita’<sup>2</sup>. In addition, the ‘total fertility rate’, as a measure of the effectiveness of family planning programs scored poorly. ‘DPT3 immunization coverage’, i.e. diphtheria, whooping cough, and tetanus which represents immunization programs and preventive medicine efforts, were also very poor. The availability of health care services as reflected by ‘access to care’ was not much better either. Taking this into consideration, it becomes clear that the ‘infant mortality’, which is determined by socio-economic factors, by the availability of health services, and also by the female education level, was very high. This parameter received a very low point value. A similar constellation can be seen for ‘life expectancy’ which can be considered a rough overall measure of a population’s health status. This received a very low score too for Tunisia in 1966. Surprisingly, however, the other mortality parameters such as ‘death rate’, ‘maternal mortality’ and ‘under 5 mortality’ performed relatively well in comparison to the other adverse conditions. The ‘adult literacy’ rate was low, too. Disaggregation of

this data shows that the female population was clearly disadvantaged. The ‘expenditure on health’ and the ‘expenditure on education’, each as a percentage of the GNP, were both relatively high in a country whose economic activity was very low. To interpret these figures it is necessary to recognize that between 1962 and 1969 the socio-economic and socio-political programs in Tunisia were based on socialistic concepts. In 1966 Tunisia had a low percentage of ‘births for women under the age of 20’. This is considered a good feature when evaluating the health conditions in a developing nation.

Comparing the 1994 health profile to the one of 1966 (see **Figure B.6**) reveals much fewer “deficits” and shows an improved pattern in almost all sectors.

To make these achievements in health development more clearly visible, the “health profile line” of 1994 is plotted on top of the health profile of 1966. The progress can be seen by the different positions on the 10 point scale for each indicator. A deterioration is seen only with respect to ‘tobacco consumption’. This might be viewed in the context of an increased economic output or in a trend towards liberalization in political and societal affairs which took place during the past two decades [9,30].

The VHIP of other countries can also be generated at different levels of disaggregation by using the same approach when sufficient data are available.

**Figure B.7** and **Figure B.8**, for example, show the VHIP of Sri Lanka, as a comparison of the highly aggregated national health profile to that of the district of Gampala and Puttalam for 1981, respectively. In **Figure B.9**, a comparison of the two districts is displayed, revealing quite different health profile patterns. Thus, it is possible to perform a district specific analysis within a country yielding a more detailed picture of the actual problem landscape than would be possible by using only highly aggregated national data. Intervention options suitable to more local conditions or problems will therefore be more easily identifiable.

### Infrastructure and services

- access to care
- contraceptive choice
- prenatal care
- deliveries attended
- infants attended

### Resources and allocation

- GNP per capita
- expenditure on health
- expenditure on education

### Effects and Outcomes

- life expectancy at birth
- maternal mortality
- infant mortality
- under 5 mortality
- adult literacy, female
- total fertility rate
- births under the age of 20
- population growth rate
- HIV prevalence (est.)

**Table B.1:** Indicator breakdown used for describing various aspects of reproductive health

Due to the underlying information system, a wide variety of comparisons among countries, regions, districts etc., including different times intervals, is possible as long as appropriate and reliable data are available.

As indicated earlier, it is possible to generate selected health profiles for specific purposes.

The breakdown of **Table B.1** is used as an example to describe and to analyze the health situation with respect to Reproductive Health [24,28]. In this example, the selected indicators are grouped within the following three domains: **Infrastructure and services**, **Resources and allocation**, and **Effects and outcomes** (see also **Figure B.10**). This indicator breakdown is by no means perfect, but gives an idea of the application potential of the VHIP approach.

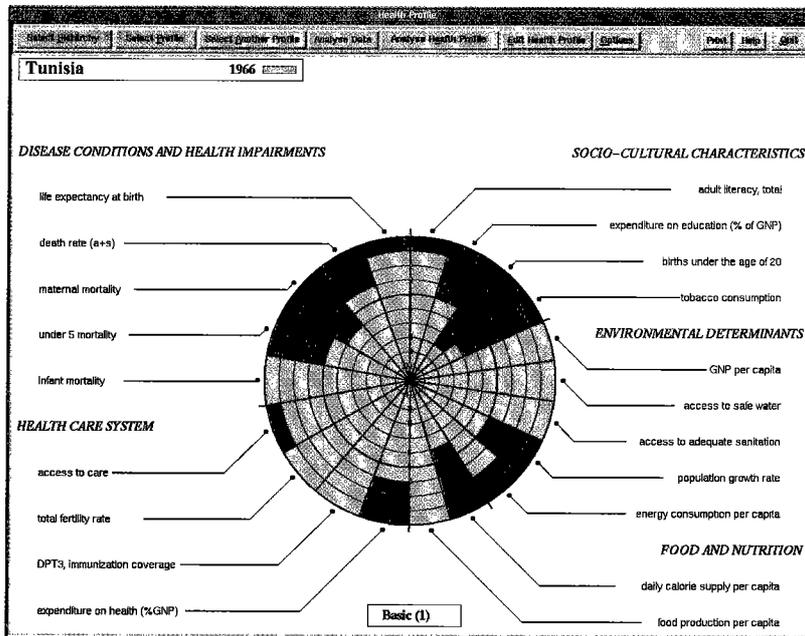


Figure B.5: The VHIP of Tunisia 1966

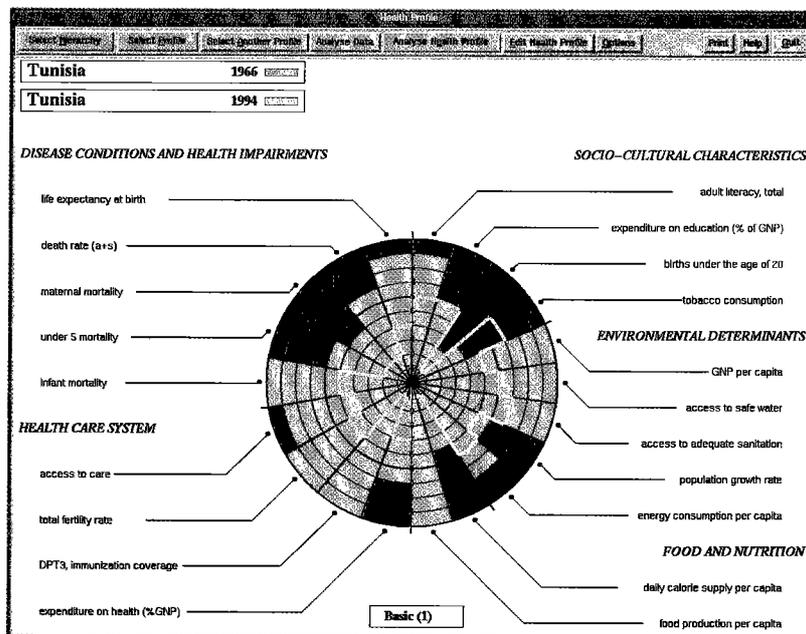


Figure B.6: The VHIP of Tunisia 1966 and 1994

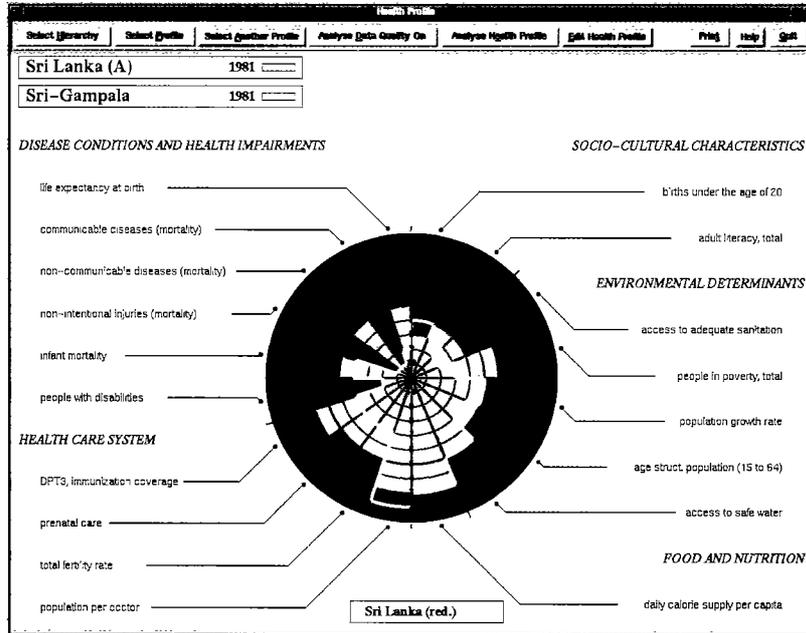


Figure B.7: The VHIP: A national-district comparison; Sri Lanka - Gampala (1981)

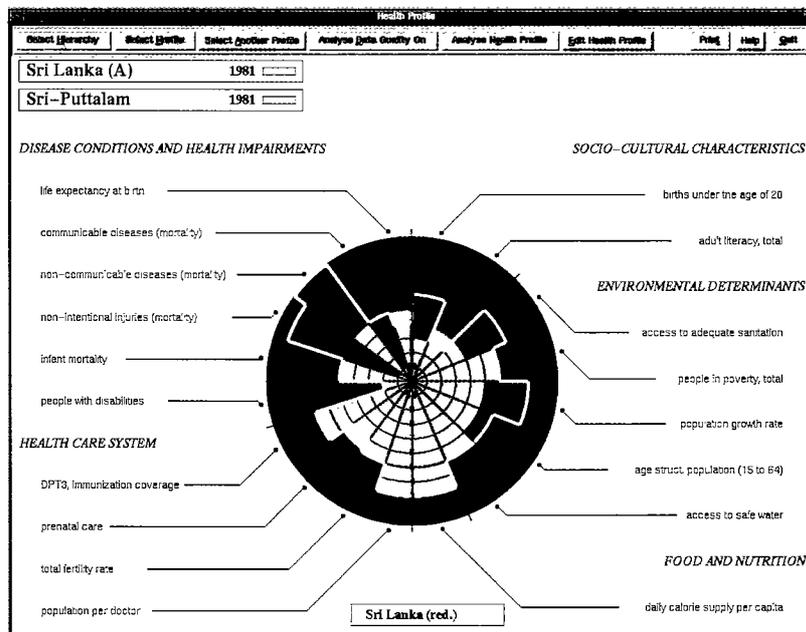


Figure B.8: The VHIP: A national-district comparison; Sri Lanka - Puttalam (1981)

The International Conference on Population and Development (ICPD) in Cairo 1994, stated that “reproductive health care is defined as the constellation of methods, techniques and services that contribute to reproductive health and well-being through preventing and solving reproductive health problems. It also includes sexual health, the purpose of which is the enhancement of life and personal relations, and not merely counselling and care related to reproduction and sexually transmitted diseases” and identified, among others, components of Reproductive Health Care including “...family-planning counselling, information, education, communication and services; education and services for prenatal care, safe delivery, and post-natal care, especially breast-feeding, infant and women’s health care; prevention and appropriate treatment of infertility; prevention of abortion and the management of the consequences of abortion; treatment of reproductive tract infections; sexually transmitted diseases and other reproductive health conditions; and information, education and counselling, as appropriate, on human sexuality, reproductive health and responsible parenthood. Referral for family-planning services and further diagnosis and treatment for complications of pregnancy, delivery and abortion, infertility, reproductive tract infections, breast cancer and cancers of the reproductive system, sexually transmitted diseases and HIV/AIDS should always be available, as required. Active discouragement of harmful practices such as female genital mutilation

## 8 Discussion

The Visual-Health-Information-Profile is an approach suitable for illustrating and analyzing the health status of a given population and for monitoring the impact of interventions designed to overcome health deficits.

An important benefit and advantage of the health profile approach is that all input data are preserved

should also be an integral component of primary health care including reproductive health care programmes” [24].

In this VHIP prototype, not all of the above mentioned aspects of reproductive health are covered, but most of them can easily be supplemented if appropriate data are available and accessible. In an experimental analysis, Tunisia and Sri Lanka were compared to each other (see **Figure B.10**). The evaluation and interpretation of these ‘reproductive health’ profiles are documented elsewhere [3].

The above illustrated applications show the potential of the Visual Health Information Profile for analyzing and monitoring health development of a population including a direct comparison between and within countries as a function of time. Comparison for “neighbor” countries with respect to geographical closeness or similarity or inequity of the health profile patterns can also be explored [25]. Evaluation of these profiles can reveal researchable issues, some of which will likely be amenable to solutions via global research initiatives.

and made available in a structured data base. Consequently, it is simple to track back from a high level domain value to the individual contributory observations or estimates at the most basic level, i.e., at the actual problem area.

However, in dealing with indicators it is important to be aware of their inherent limitations. The choice

and evaluation of the indicators employed in each domain always need careful consideration. Data availability, reliability, and validity as well as standardized data collection methods are prerequisites for every evaluation based on statistical information. The utilization of expert judgment whenever quantitative data are suspect, not available or not relevant, is an important feature of this approach.

To reduce redundancy of indicators, a more sophisticated list of 'essential' indicators and comprehensive class proxies should be developed

## 9 Conclusion

A prototype Visual Health Information Profile was developed which incorporates specific health- and health-related data and reflects the multi-dimensional nature of health. A decile-based scaling method allows the simultaneous visual presentation of a wide range of health-related measurables and health status indicators. Health profiles can be generated for most countries in the world thus providing the opportunity for international comparisons as well as for monitoring health status changes over time within selected countries.

While detailed listings of statistical data are important in documenting existing information, the impact on public officials is enhanced through the visual summary of relevant information. The profile pattern can raise questions that call for answers, can reveal interrelationships among various health

on a multi-disciplinary basis to establish a sensible indicator framework.

It should also be recognized that the presented approach while vulnerable to oversimplification of the actual situation is practical and robust. However, the VHIP can be supplemented over time with new indicators and will improve steadily as its components become more meaningful. The framework for managing and monitoring the overall health status of a population will thus improve as well.

domains and can lead to new scientific hypotheses regarding the improvement of global public health through multidisciplinary collaboration.

The VHIP is considered to be a managerial tool which can be used by public officials to identify needs, can be used by administrators to allocate resources, and can be used by policy-makers to clarify where health problems originate. It can also facilitate and improve the dialogue between decision-makers and scientists.

Although the VHIP prototype needs some more refinements, it is already a helpful and valuable new method which can be applied in the global health planning process.

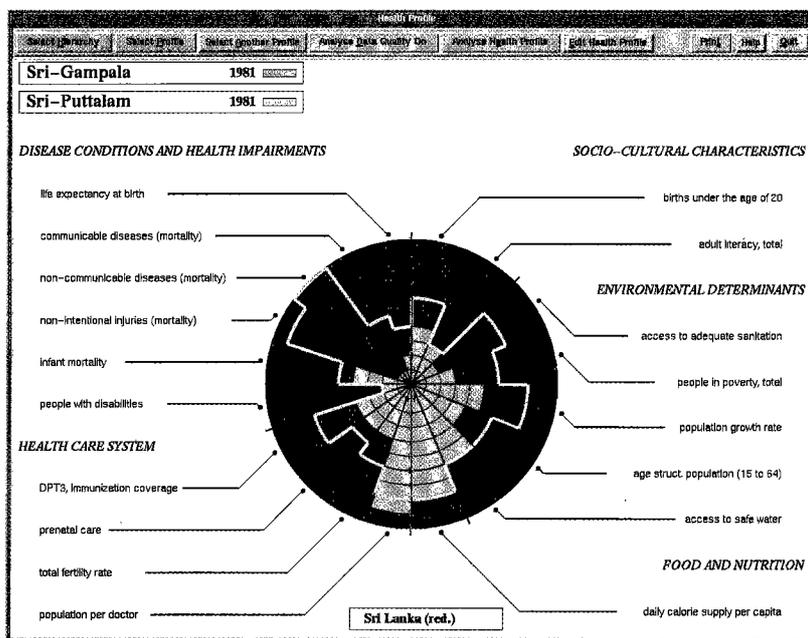


Figure B.9: The VHIP: A comparison of two districts shown in the previous figures (1981)

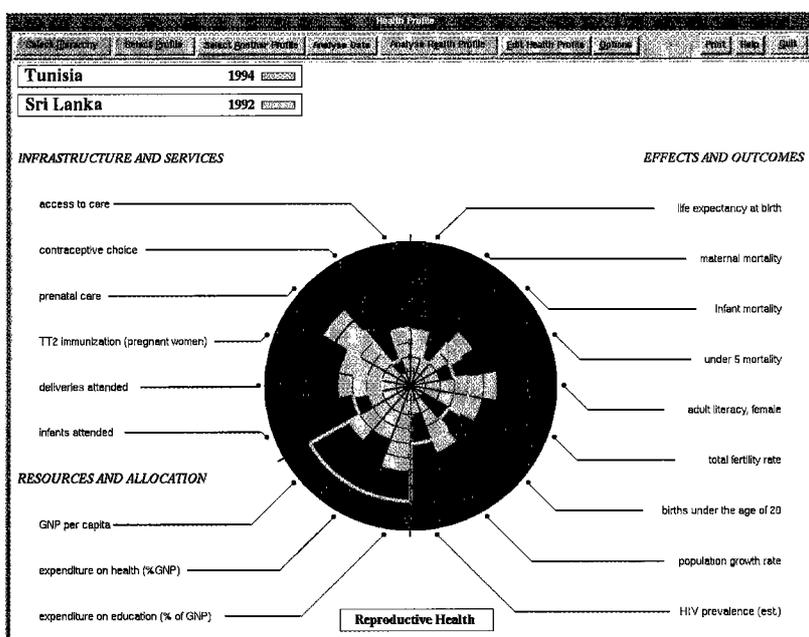


Figure B.10: The VHIP for Reproductive Health of Tunisia 1994 and Sri Lanka 1992

## 10 Acknowledgments

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## 11 Annex

Tunisia - Absolute Values (provided by Dr. Fakhfakh)	1966	1975	1984	1994
<b>Disease Conditions and Health Impairments</b>				
Life expectancy at birth, total	51	58,6	67,2	71,2
Death rate (age + sex standardized)	1120	920	569	523
Maternal mortality rate	500	300	150	68,9
Under 5 mortality rate	47,9	30,5	15,1	9,3
Infant mortality rate	140	104	51,6	30,6
<b>Health Care System</b>				
Access to health care (% of population)	50	85	90	90
Total fertility rate (births per woman)	8	6	4,64	2,87
Immunized: DPT, under 12 months (% age group)	10	40	61	97
expenditure on health (%GDP)	2,5	3,2	4,2	4,9
<b>Socio-cultural Characteristics</b>				
adult literacy, total	32,1	45,1	53,8	67
expenditure on education	4,5	4,9	4,3	4,8
births under the age of 20	7,1	5,6	4,6	3,1
tobacco consumption	1,77	1,81	2,44	2,17
<b>Environmental Determinants</b>				
GNP per capita (US\$)	230	770	1160	1800
access to safe water	14,2	26,4	49,4	68,3
access to adequate sanitation	12	20,7	29,9	39,5
population growth rate	2,17	2,11	2,11	1,82
Energy consumption per capita (kg of oil equivalent)	200	329,89	510,33	590,36
<b>Food and Nutrition</b>				
daily calorie supply per capita	2400	2543	2276	3333
Food production per capita (1987=100)	69,52	114,55	83,1	110
<b>Tunisia - Point Values (PV)</b>				
<b>Disease Conditions and Health Impairments</b>				
PV- Life expectancy at birth, total	2	3	5	7
PV- death rate (a+s stand)	4	5	9	9
PV- Maternal mortality rate	6	7	8	9
PV- Under 5 mortality rate	5	6	8	9
PV- Infant mortality rate	1	2	4	6
<b>Health Care System</b>				
PV- Access to health care (% of population)	2	6	7	7
PV- Total fertility rate (births per woman)	1	2	4	6
PV- Immunized: DPT, under 12 mths (% age group)	1	2	3	10
PV- expenditure on health (%GDP)	4	6	6	7
<b>Socio-cultural Characteristics</b>				
PV- adult literacy, total	2	3	4	5
PV- expenditure on education	5	6	5	5
PV- births under the age of 20	8	9	10	10
PV- tobacco consumption	7	6	3	4
<b>Environmental Determinants</b>				
PV- GNP per capita (US\$)	1	4	5	6
PV- access to safe water	1	1	3	5
PV- access to adequate sanitation	1	2	3	4
PV- population growth rate	5	5	5	6
PV- Energy consumption per capita (kg of oil equiv)	3	4	5	5
<b>Food and Nutrition</b>				
PV- daily calorie supply per capita	6	6	5	10
PV- Food prod. per capita (1987=100)	1	10	1	10

**Table B.2:** Absolute data of selected indicators of Tunisia for the time series 1966, 1975, 1984 and 1994 including the corresponding decile-based point values (PV).

Indicator	Point-Values										
	1	2	3	4	5	6	7	8	9	10	
life expectancy	less	49	56	62	67	69	70	72	74	76	more
death rate (a+s)	more	1831	1557	1237	929	806	737	675	575	488	less
maternal mortality	more	1471	900	800	626	511	373	204	140	48	less
under 5 mortality	more	178	134	78	58	40	24	20	12	9	less
infant mortality	more	110	84	57	43	31	20	15	10	8	less
access to care	less	40	55	67	75	85	90	95	98	100	more
total fertility rate	more	6,6	5,7	4,9	3,9	3,1	2,7	2,2	1,9	1,7	less
DPT3, immunization coverage	less	37	59	68	75	82	85	89	91	95	more
expenditure on health (%GNP)	less	1,1	1,9	2,1	2,9	3,2	4,6	5,3	7	9	more
adult literacy, total	less	32	41,7	52	62,4	73,1	80,7	88,4	95,3	97,7	more
expenditure on education (%GNP)	less	2,3	2,9	3,7	4,2	4,9	5,4	5,9	6,6	7,7	more
births under the age of 20	more	19	16	14	13	12	10	8	6	4	less
tobacco consumption	more	3,2	2,9	2,4	2,1	2	1,8	1,5	1	0,9	less
GNP per capita	less	290	415	703	1073	1497	2358	3208	7583	19698	more
access to safe water	less	34,2	46,4	57,6	64,3	77	86,2	90	95	100	more
access to adequate sanitation	less	17	23	35	48	58	64	74	83	92	more
population growth rate	more	3,2	2,9	2,6	2,2	1,9	1,4	0,9	0,6	0,1	less
energy consumption per capita	less	40,4	104,1	233	435	661,6	1376,6	2191,9	3382,7	5122,1	more
daily calorie supply per capita	less	1883	2021	2202	2265	2390	2587	2685	2824	3144	more
food production per capita	less	86	91	92	96	99	101	104	107	114	more

**Table B.3:** Table used for transferring absolute data into relative point values. The decile limits are given for each indicator.

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# Annex C

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## Telematics in Support of the Implementation of WHO's Research Policy Agenda

### Abstract:

This paper describes the role of health telematics in planning for global health development. It does so, first, by defining health telematics and by discussing some key factors which will influence the way in which health telematics supported research can be used for global health development. Some methodological examples of how the Research Policy Agenda can be implemented are then presented, so as to provide a foundation for discussions concerning a practical health research planning policy for the World Health Organization (WHO).

The paper describes a framework for systematically developing a strategy for introducing health telematics within a national or regional health organization. It suggests that a gradual evolution is necessary, given both the complexity of introducing integrated systems, and the ability of people to fully utilize them.

### 1 Introduction

#### 1.1 Health telematics defined

Various terms have come to be used to denote the use of telecommunications technologies in research for, and the delivery of, improved health care. The most common terms include *telemedicine*, *telehealth*, *telecommunication for health care*, and *telematics in medicine*. That they are largely synonymous is illustrated by the substantive and methodological overlap of the relevant publications [9]. Their use depends to some extent on whether one is a physician, a non-physician health or education professional, an engineer, or an informatician, respectively.

In a recent report [37], a WHO group consultation defined **health telematics** as: „*a composite term for health-related activities, services and systems, carried out over a distance by means of information and communications technologies, for the purposes of global health promotion, disease control and health care, as well as education, management, and*

*research for health*“. It went on to state that the general concept of health telematics includes four specific functional areas: tele-education, telemedicine, telematics for health research, and telematics for health services management. The area of interest here is health telematics as it applies to research.

According to the report, telematics for health research „comprises a variety of scientific activities aimed at solving health problems, including:

- Collaboration and networking among individuals and centres for the sharing of ideas, results and access to core competencies, information and knowledge bases;
- Development of new telematics technologies and applications;

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- Evaluation and validation of health telematics and its effects on individuals, societies and health disciplines.”

The same report recommended (Recommendation 6) that WHO member states should “use

health telematics as a means to address their information needs and health care requirements, and to specifically include health telematics in their overall *planning* for health development, education, *research programmes*, and telecommunications” (emphasis added).

## 1.2 Health telematics and the transfer of knowledge

As indicated in WHO document EB99/30 [38], there are two imperatives in the health sectors of nearly all countries: to improve access to quality health care, and to control costs of health service delivery. By optimizing the utilization of research resources and by *facilitating the transfer of knowledge*, health telematics may help to accomplish both. Through the provision of services that not supply information but also assist in its interpretation and application in different contexts. To demonstrate just how this can be done will itself require research efforts; ones which should be stimulated by, or conducted under the aegis of, WHO's Advisory Committees for Health Research (ACHR).

The need for such knowledge transfer is clear, evinced by the dramatic disparity in health research, medical education, research knowledge and skill between developed and developing countries

[35]. Poor countries, working with technologically advanced allies, are using health telematics to strengthen research and planning, health care delivery and professional education available within their own borders [29].

A broad spectrum of knowledge transfer scenarios are conceivable, especially in the area of health research planning. WHO, working with the international health telematics and research communities, is in a position to develop and promulgate practical guidelines for the establishment, maintenance and evaluation of health telematics links for research. WHO policies in this area could increase the probability that health telematics will ultimately provide a viable form of ongoing and cost-effective support to medical and health care research, service delivery, technology assessment, program evaluation, and continuing medical education.

## 1.3 Learning from market-driven business processes

Outside of the health field, there already exists much experience with the technical and administrative aspects of telematics. Telecommunications and information technologies have been having an impact on commercial, managerial, educational and research processes for several years [33]. Even the health field itself, while stable and productive systems are still few and far between, boasts a very large number of experimental initiatives and pilot projects from which valuable experiences and

lessons may be learned [4]. It will be important to explore these sources intensively, as one of the cardinal principles underlying *health* telematics, as opposed to profit driven processes, is that system instability or failure will permanently damage the credibility of the implementer in the eyes of the health researcher or health care professional. Having struggled to cope with the technical aspects of telematics, researchers in developing countries can be expected to have a degree of commitment to the

technology only as long as the high expectations built up by the informatics implementers are met consistently, after the system is put to practical use - a situation which is sadly very uncommon. One needs only to imagine the effect on a surgeon of having a critical information link to a remote specialist collapse during surgery. It may be a long time before he regains any interest in the technology. And it will then be the perceived utility of the technology itself, independent of the telematics personnel who may have bungled the implementation, which will be severely impaired, if not destroyed, in that arena. This must be avoided at all costs. It will be better to defer the implementation of a technology until it is demonstrably more stable, rather than jeopardize research and health interventions by premature implementation.

Luckily there are many safety-critical applications of informatics and telematics from which one can and must draw the guiding experiences. Computer-supported cooperative work (CSCW) has been shown to be very effective in large R&D projects. Boeing recently developed its 777 airliner essentially without the use of paper - all work was done on computer using CSCW processes. The one time that paper was used was for the signing of the contract to do the work [32].

The linking of remote researchers has also been achieved with some regularity. Prof. J. Rantanen (Finland) heads up an occupational health research

facility which is scattered around the globe. This unit has been functioning well for many years and provides one excellent model for the research networks needed by WHO [36].

It will also be necessary to support local researchers, and later health professionals, by providing them with telematics links to remote sources of support, be this in the form of advice, databanks, software programs, or knowledge. SatelLife's HealthNet program has been using a large range of telematics applications in order to support clinicians around the world with medical literature and other assistance via satellite services (Cf. <http://www.healthnet.org>). This non-profit organization stands ready, willing and able to provide guidance to researchers working on global health issues.

In addition, many companies in industrialized countries have been experimenting with telework, where employees are able to perform many if not all of their duties from a site remote from the employer's usual place of business. While this modality creates as many social and ethical problems in the regular workplace as it solves, nevertheless the technological and administrative lessons learned from these experiments will go a long way toward helping us understand how processes similar to telework may best be employed in research for health development.

## 2 Factors affecting Implementation of telematics

Before telematics for global research can be discussed in specific detail, it is useful to briefly define some of the main factors which will influence the way the various technologies involved will affect

implementation. Such factors can be grouped under the headings of technical, human and ergonomic, ethical, and policy factors.

### 2.1 Technical factors

The adoption of telematics has been slowest in the health services. This is particularly true of

research and has a number of technical reasons [19] which are described below:

The **number and variety of existing hardware and software products** and components which are directly applicable in the area of telematics is vast. A comprehensive discussion or evaluation of these would be outdated before it was published. On top of this, the ongoing advances in telecommunication and information technologies are so frequent, numerous, and complex that were such a list to exist it could not be kept up to date.

Some telematics-relevant products, and even **technologies, may be abandoned** by manufacturers because the total market for such items is too limited to justify product support or because business priorities have shifted. The cited text mentions that the abandonment by AT&T of PICASSO, a simple and inexpensive still-image phone system, caused concern among the military establishment. Even some picture archiving and systems (PACS) may be threatened because of manufacturer and vendor concern "about returns on expensive but slow-to-pay-off investments".

Uncertainty with regard to how national regulatory agencies in the developed world (e.g. the US Food and Drug Administration) are going to deal with **medical software**, will affect the use of health telematics software in other parts of the world. In a developing country, it will be difficult, both practically and ethically, for telematics advisors from the richer countries to advocate nation-wide acceptance of a piece of medical software which is not cleared for general use in the state of origin. Here the issue of software engineering quality control becomes a key factor - will ISO 9000-3 or similar related standards be universally accepted and used?

As health services are only part of the market for telematics technologies, some **features of some telematics products will be clinically useless**, adding unnecessary cost. The massive adoption by commercial interests (banking, entertainment, retail, etc.) of such medically-relevant technologies as smartcards, hand-held computers and decision-

support systems, "may dominate technical, pricing and other decisions" [19]; this means that clinical utility, patient acceptability and health impact would not be the governing factors in design.

Not only will user needs and circumstances will vary enormously from country to country, making it difficult to determine which technology or combination of technologies is the best fit in each situation, but the sheer variety and complexity of the technologies concerned will present **serious technical challenges**:

- "the rapid pace of technological change affecting the hardware and software options;
- the multiplicity of hardware and software options and pricing schemes;
- the scarcity of standards to assure that different hardware and software options will work together well;
- the requirements for specially adapted space, extensive use training and reinforcement, and sophisticated support staff;
- the diversity of needs and circumstances among users within an organization; and
- the need to develop a variety of communications links with "outside" organizations and individuals that differ in the capacities and configurations of their systems" [19].

The area of hardware and software standards in support of health telematics will require ongoing research. Standards such as the ACR-NEMA's DICOM for medical imaging, HL7 for the exchange of clinical data, and ISO 9000-3 for software quality, will be key aspects of international health telematics policy. International agreements on standards will not be easy to reach.

Finally, there is the problem of technological obsolescence, the natural corollary of rapid

technological advances. The determination, acquisition and implementation of technological configurations for specific national and regional needs, as well as the concomitant upgrading and maintenance contracts, must be done with more care than would be the case with commercial systems - national health development must not be jeopardized by adventures in telematics.

## 2.2 Human and ergonomic factors

“Most failures of telemedicine programs are associated with the human aspects of implementing telemedicine” [Allen and Perednia, 1996; 19].

In implementing a health telematics project or facility for health research, it will be necessary to keep the **human factors** in mind. It will be important [19]:

- to avoid technology-driven projects; of primary (or exclusive) importance are the needs and preferences of researchers, health care professionals, and managers;
- to document cost savings and other benefits for researchers and administrators;
- to recognize the possible lack of professional readiness for this technology - especially on the part of those directly responsible for designing and conducting health research using telematics software and equipment;
- to choose or design hardware and software configurations which are user-friendly;
- to allow adequate time for training;
- to focus on the appropriateness of telematics technology, rather than on cost;
- to prevent vendor- or market-driven purchases; and

Work underway in Alberta [1] identifies some strategies for resolving some of the basic technical and infrastructure issues. These deal with a) research into inter-connectivity and standards for interoperability, b) use of pilot sites for testing and evaluation of health telematics, and c) creation of a body to monitor network operations and costs.

- to give more attention to applications-driven design, human factors engineering principles, and business process re-engineering.

As a service, health telematics in the form of a research planning support mechanism is even more difficult to provide than ordinary, single- or multi-site research. For a start, the **communication difficulties** existing between a developed country and a developing one introduce deferential strains which have to be guarded against. In addition, there are many communication gaps which have to be dealt with: gaps of distance, of conflicting perspectives, of differing values, of economic reality, of perception, and of meaning. Providing health telematics in support of research programs will require careful attention to cultural and professional (perceived and real) differences.

In addition, considerable discussion has been devoted to the requirement of such systems to incorporate culturally-appropriate software, with particular attention to the linguistic and social characteristics of the community in which they are to be used. While cultural differences will inevitably complicate the already difficult early stages of health telematics initiatives in research planning, and impose barriers to their success, this technology can also help in bridging cultural and linguistic differences between health researchers and planners working across cultural boundaries. But, to do so, the telematics applications must be user-friendly and

culturally-appropriate. At this time there is little evidence in the literature that these dimensions of health telematics systems have been addressed systematically or effectively.

Another requirement is that health telematics equipment be designed and implemented according to sound **ergonomic** principles, and that the software

### 2.3 Ethical factors

Health telematics innovations have a high probability of being involved in decisions and actions which could jeopardize the rights and freedoms of present and future generations, and thus adversely affect the health or lives of people around the world. The practice of research using health telematics will therefore present special **ethical problems**. Maintaining the confidentiality of information, and safeguarding the integrity of information systems, will present ongoing

### 2.4 Policy and planning factors

There are some important policy and planning aspects of how to make health telematics a central component of research and planning activities. Several dimensions will need to be considered, including planning and monitoring, national and international regulations, professional, assessment, and financial.

The overall research and planning process will itself have to be subject to systematic and consistent **planning and monitoring**. The structures and procedures to accomplish this will be described below.

The cross-border flow of data and information will be subject to a variety of **national and international regulations**, such as international telephone agreements. The use of health telematics

be easy to use. It is one thing for health telematics enthusiasts to put up with complicated equipment, unreliable operating systems, sluggish networks, or the idiosyncrasies of unique, stand-alone systems. It is quite another matter when such systems are to be implemented in developing to provide practical and reliable research support to planners, care givers, physicians and managers.

challenges. Large-scale informatics and telematics issues will also be unavoidable, such as those involved in the use of population databases [8]. In addition, it is possible that cultural differences among participating countries (and professionals) will have an impact on what is perceived as ethical. Policies to foster the effective implementation of health telematics for research and planning in developing countries must take such ethical requirements into considerations.

for research and planning, regular delivery of health care and continuing medical education may therefore have to be incorporated in the respective rules and/or exemptions. Appropriate WHO policies may facilitate this process. The practice of medicine and related research is governed by national and provincial regulations. The conduct of research over a distance may, for some time to come, be surrounded by debate and contradictory regulations. These will have an impact on the efficient practice of health telematics, and may, from country to country, limit the utility of health telematics for research.

It is likely that a variety of national and trans-national for-profit corporations will be enlisted as partners in the provision of health telematics links and services. Their support of non-profit services

will necessitate consideration in any health telematics policies.

Policies in support of health telematics should include provisions recognizing variation in standards for professional research **credentials**. Designing and conducting research across distance leaves open the question as to who will assume responsibility for the accuracy, and/or quality of the research conducted. Given the wide variation in research qualifications around the world, not to mention the variability in socio-cultural and personal expectations, it will be necessary to take account of the amount and quality of research training received by those who will be at the less-developed end of the health telematics link. Variations in credentials will also have to be acknowledged in the activities of any health telematics research network.

The regulation and **assessment** of hardware and software is also an important policy issue in the implementation of health telematics. Rapid advances in the number and complexity of telematics components will require inclusion of safety and performance factors in the policies to be considered by WHO.

There will also need to be discussions about the **financial aspects** of health telematics, especially as they relate to research institutions in developing countries. Issues which need to be considered for incorporation in international policies include: the remuneration of researchers and staff at either end of the network link, the funding of telematics development and research projects, fiscal adjustment of research budgets and resource allocation, and the costs of building and maintaining research infrastructure.

## 2.5 Implementing WHO's Research Policy Agenda using health telematics

The foregoing factors imply that some key questions will have to be answered when implementing network-based research and research planning efforts:

### Technical

- What telematics design, specification, development (or purchasing), and implementation practices will lead to telematics systems which are determined by clinical utility, patient acceptability and health impact?
- What standards should be used with regard to telematics hardware? How can they be monitored and maintained?
- Should software engineering quality be controlled with ISO 9000-3 or similar standards?

### Human and ergonomic

- How can basic training and skills up-grading programs be designed and used to maximize the probability that research capacity is effectively built up in developing countries?
- What processes can be developed to ensure that health telematics installations are user-friendly and ergonomic?
- How to ensure that services developed in different regions are sufficiently standardized to facilitate knowledge transfer between regions?

### **Ethical**

- What steps can be taken to minimize the risk that research-oriented telematics and informatics can be abused to the detriment of human rights and quality of life in developing countries?

### **Policy and planning**

- How can the planning and monitoring of research for global health development be conducted in a sustainable and transparent manner?
- What technical and organizational processes would facilitate harnessing global 'science and technology' in the form of a community of collaborating researchers?
- How will the necessary research processes and research networks, to be supported by health telematics, be created?
- How will these research processes and research networks be maintained over the long term?
- What steps must be taken to construct and maintain a knowledge-base for collecting, analyzing and disseminating information about regulations and laws regarding inter- and intra-national telematics for health research?
- How can the wide variety, in content and quality, of professional credentials be harmonized into a workable protocol of equivalencies?
- What can be done to upgrade the training of comparable professionals holding non-equivalent credentials, when this is required by considerations for patient safety, research quality, or by the demands of sponsors, funders or publishers?
- When and how should health telematics implementations be evaluated?
- Who should bear the ultimate responsibility for ensuring that the quality of health telematics-supported research carried out in the context of WHO's Health for All program is monitored and reported?
- How will various funding options affect the design and conduct of telematics-supported research for health development?
- What effect will telematics have on the cost of research?
- What arrangements can be made with telecom operators to reduce the cost of telecommunication links used for research in developing countries?

The answers to such questions will provide much of the structure and processes needed if global health development is to be facilitated with research.

## **3 Conceptualizing health telematics for research planning**

Having considered the nature of health telematics and the factors which could affect its implementation, it is useful to examine the structures and processes (form and function) which would deal with the kinds of questions posed when health telematics is used to support the implementation of WHO's Research Policy Agenda (for further

background information it is referred to [10,23, 25, 34,31]). Two kinds of processes suggest themselves: (1) a research planning and monitoring process describing how the WHO's ACHR system would work with the various partner groups to ensure that appropriate research targets are identified, effective research teams established, and useful research

projects conducted and reported; and (2) the actual research structure and process which would begin with an identified research target and yield one or more clear conclusions of direct utility for global health development.

### 3.1 Research planning objectives

The major objectives of using health telematics in the planning and conduct of research might include:

#### 1. To improve planning and decision making by

- better access to knowledge and expertise resulting in higher quality services,
- better history or organization memory leading to better decision making,
- awareness of current planning status leading to better contributions to plans,
- improved communication leading to wider consensus,
- quicker and higher quality decisions through sharing of viewpoints.

#### 2. To encourage focused research by

- better ability to focus on problems through improved awareness,
- easier access to experts,

Before describing in detail what such components should look like, we have to specify what the objectives of such a research planning framework might be.

- better exchange of information,
- a more detailed analysis of ways to improve work practices within each activity is the carried out and technologies are suggested to lead to improved work practices.

#### 3. To foster collaborative research by

- improved coordination encouraging joint research,
- enabling computer-supported discourses,
- providing access to many knowledge resources,
- empowering individual researchers in knowledge assessment and compilation.

More generally, the work of the ACHR-system itself, as well as that of many national health services will benefit from the use of health telematics because research expertise can be widely distributed where and when decisions require access to research expertise and other resources.

### 3.2 Planet HERES: A process for planning health research

The first of the two processes, i.e. a research planning process for health development, has already been developed at the University of Ulm. It is called Planet HERES [15,17], an acronym which stands for 'Planning Network for Health Research'. It is intended to work in close cooperation with WHO's

ACHR system and oversee the total research (planning) process [11,30], from priority and funding considerations, over the identification, selection and coordination of research teams, to the inception, maintenance and monitoring of projects.

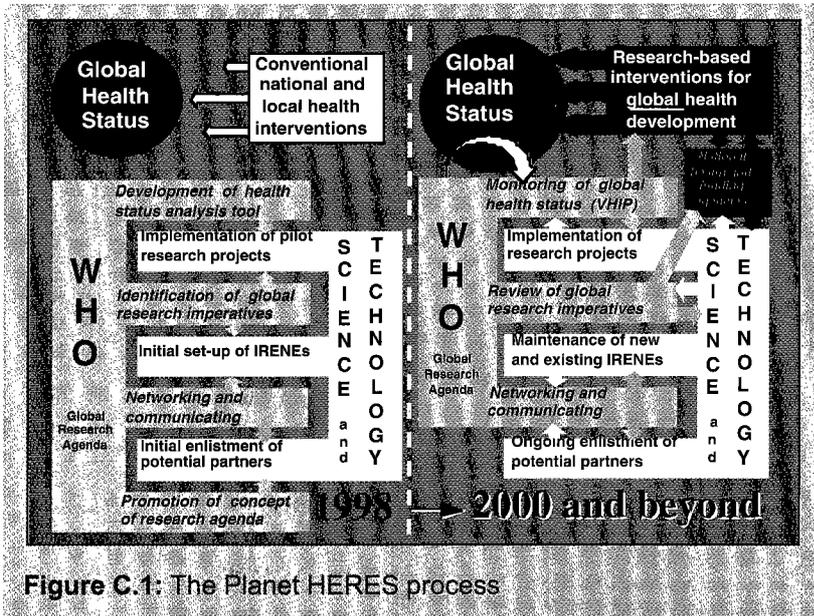


Figure C.1: The Planet HERES process

The creation and practical implementation of this process will require considerable effort and commitment from all concerned, if it is to become successful. **Figure C.1** was drawn up to illustrate the structural and functional relationships which might best serve as a process to implement WHO's Research Policy Agenda and facilitate research planning for health development. As the conduct of the research itself can only be done with extensive research personnel and facilities, neither of which WHO has, it is the purpose of the research agenda to lay out a framework according to which research can be initiated and catalyzed. The overall content of Figure 1 is thus of Research Policy Agenda as an initiator and catalyst of research for global health development. The actual investment of time and effort must ultimately be provided by the world's substantial complement of research professionals, and funded by national and international organizations and agencies. However, such a cooperative and systematic approach to dealing with global health problems is at present lacking. Although there is much research activity in the developed countries, not enough of it is aimed at finding practical solutions to the sustainable improvement of health in developing countries.

WHO, recognizing that a more concerted effort is needed to encourage and facilitate the collaboration of researchers, saw it as part of its mandate to create a process to do this. It was also clear that, once started, this process should be driven more from the community of researchers than from WHO. Accordingly there are two phases to the process described: Phase 1 (1998 & 1999) and Phase 2 (2000 and beyond). Phase 1 involves the establishment and promotion of the research agenda, and calls for WHO to instigate and control much of the action. Phase 2, on the other hand, involves less direct pressure from,

or stimulation by, WHO, calling instead for systematic action being organized and promoted from the world's science and technology community. The difference between the two phases shown in **Figure C.1** is described more fully below.

The diagram reflects two phases, before and after a successful implementation of WHO's Research Policy Agenda with the Planet HERES process. It illustrates the improvements in global health development (sharp red arrows impacting on an enlarged green circle), resulting from effective health interventions (red-colored box) based on research project funding received from national health and funding agencies (green box). This funding has been achieved with input, in terms of demonstrated research competence, from the scientific community (yellow E) and with the assistance of the WHO/ACHR process (light blue E) which provides priorities based on the ACHR-based assessment of global health research imperatives (priorities). The whole process, i.e. setting up and monitoring both interlocking E's, is referred to as Planet HERES.

There are three main differences between the left

and right-hand parts of **Figure C.1**. The first is that the operational processes shown in the right-hand part of the diagram are shown in their initialization phase in the left-hand part. The second is that the fourth crossbar of the blue E in the left-hand diagram, illustrating the promotion of the research policy agenda concept, disappears in the right-hand version because the concept has been accepted and is active. The third difference between the two halves is shown in the upper portion of the respective graphics. Here the '2000 and beyond' (right-hand) part of the figure shows a complexity of interactions: health interventions making a greater impact on global health status due to formal links to research, to the scientific community, to coordinated funding efforts, and to the WHO/ACHR monitoring process; the latter being illustrated by the curved white arrow, signifying the use of the visual health information profile (VHIP) also developed in Ulm [5,6]. The left-hand portion of the graphic shows the baseline (pre-1998) status of the Planet HERES process, when the upper aspects of the structure are devoid of the partnerships arranged and monitored by Planet HERES and show the uneven impact (ragged white arrows) of health interventions unsupported by a research planning process.

### 3.3 IRENE: A structure for conducting health research

In order to make an impact on the serious and refractory health problems which will plague the global health situation for the foreseeable future it will be necessary to harness the power of science and technology in a series of concerted research initiatives and programs. Given the increasing shortage of cash for travel and large mobile research efforts, it will clearly be important to develop a novel approach so as to allow university-based researchers to work with their colleagues in the developing world without necessarily engaging in a lot of site visits or other travel. The only way this can be done is with the intensive recourse to health telematics via its sub-field *tele-research*.

There is a further, subtle, distinction between the two halves of the diagram. It might be noted that in the left-hand diagram the small arrows between the crossbars of the two interlocking Es form blue pincers acting on the yellow legs of the science and technology E. This is meant to show that, in the initial phase, the WHO/ACHR and Planet HERES processes, acting in concert, will have to assume much of the responsibility for organizing and mobilizing the science and technology community to take part in research for global health development. The '2000 and beyond' part of the diagram has no more blue pincers; in fact, the only remaining pincer arrows are where the international community of scientists puts demands on the networking and communications aspect of the Planet HERES (WHO/ACHR) process, for the purpose of further enlistment of research partners and the maintenance of new or existing Intelligent Research Networks (IRENEs).

These IRENEs have not been mentioned thus far. They are shown on both yellow Es, second crossbar from the top. These are discussed in the next section.

In order to come to grips with the challenges presented by the research objectives being contemplated, the authors conceptualize a new research model: the intelligent research network, or IRENE:

“What is most essential and, when compared with most other research modalities, unconventional and innovative, is that the proposed research networks should focus on the delivery of directly useable findings. This will maximize the chance that practical and effective solutions can be suggested to the decision-makers and practitioners responsible for health care delivery and related systems. In order

to accomplish such an admittedly ambitious goal, these new networks must be created, managed and monitored using, on the one hand, sophisticated technologies and, on the other, appropriate and user-friendly ones. To help with the practical and rapid establishment of these networks, several criteria (listed here in rough order of importance to the concept) have been formulated as follows:

- 1) **Intelligent:** The networks must be intelligent - in the sense of incorporating 'smart' software components to facilitate rapid, continuous and accurate exchange of decision- and safety-critical information, and to permit easy and dependable interaction of participating researchers;
- 2) **Intelligence-oriented:** The networks must attempt to seek out, define, and generate *intelligence* (i.e. policy- or decision-critical information), not just mere data or information (or even knowledge) - because today's global health problems urgently require decisions, as well as policies (en)forcing such decisions;
- 3) **Informatics-based:** The networks must be structured around the aggressive use of *informatics* (information technology and systems) - telematics being a critical sub-discipline;
- 4) **Inter-disciplinary:** The networks must be *inter-disciplinary*, as no single discipline can hope to elucidate or make significant progress against multi-causal health problems; and
- 5) **International:** The networks should be *international*, to allow the global integration of findings and experience (as most health issues have international implications), and to make maximum use of international funding avenues;
- 6) **Integrated:** The networks should, wherever possible, be *integrated* with other research efforts - as the relevant health problems which are meant to be controlled are multifactorial and not amenable to solution by a single research effort.

These six characteristics have been combined into the concept of an **I**ntelligent **R**esearch **N**etwork or **I**RENE, where the 'I' stands primarily for *intelligent* and *intelligence-oriented*, and secondarily for the other attributes listed above" [7,8,9].

The precise structure and function of IRENES will vary from case to case. The essential criteria for an IRENE will, however, remain the same [14]. Researchers distributed around the world will work together, using telematics, to address themselves via research, development and implementation (RD&I) to the solution of global problems. They will be coordinated and monitored by the Planet HERES system, which will also assist in the acquisition of the necessary funds, the coordination of the required international communication links, the evaluation of process and product, and the dissemination of the resulting findings. The software and hardware used will be state-of-the-art, involving 'smart' components wherever possible.

### 3.4 Adoption versus adaptation of telematics technologies

Policies regarding the adoption versus the adaptation of health telematics for research must be considered. Health telematics must be adapted to serve organizational needs. It would seem to be a straightforward matter to simply adopt a service such as e-mail, or video conferencing. This, however, may not be as easy as it appears, because busy users tend to resist modifying their practice or habits to suit a technology. The technology must be adapted to *their* needs, and this adaptation may require considerable effort. Adapting e-mail for discussion support can, in itself, require considerable coordination, which can be provided by more sophisticated tools such as discussion databases or workflow systems. Proper analysis is then needed to identify the processes

that can directly benefit from communication and decision support systems [24] and to adopt the most appropriate technologies to provide such support - or to adapt existing technologies to the needs of individuals or organizations.

The adaptation and/or adoption of health telematics will be gradual as busy users learn to use them in their daily work [2,27]. However, this paper proposes that a technological evolution must be planned within a strategic framework which will align technical services to organizational goals. This will give a rational basis to a technological evolution. Thus, new services will be added and enhanced to achieve the agreed-upon goals in a shorter time.

## 4 Implementing health telematics in research planning

Having discussed some of the more general aspects of using health telematics in research planning, we now focus our attention on several more specific issues. These may be useful in actually setting up a health telematics framework for research planning.

A systematic process for choosing from a variety

of technologies is presented. The authors next define the processes used in attaining selected goals and determining how process work practices can be improved. Alternative ways of achieving improvements through health telematics are also proposed. Finally, some implementation issues are considered.

### 4.1 An integrated approach

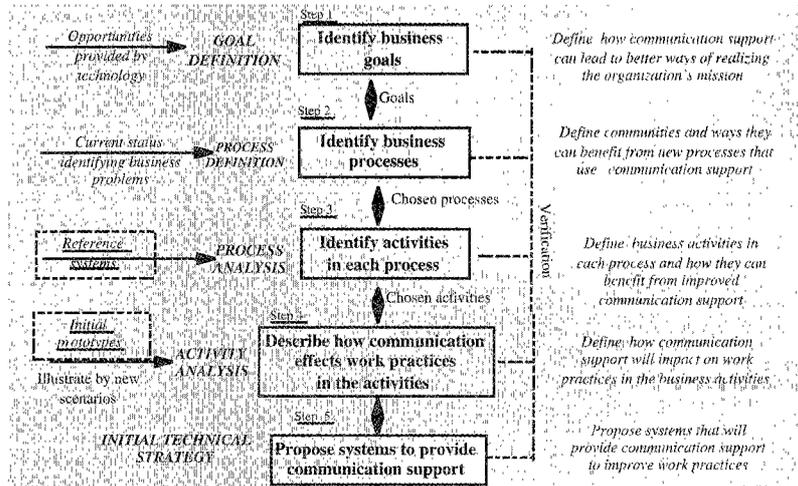
The adoption of health telematics will be gradual as busy users learn to use it in their daily work practices. However, this report proposes that an evolution must be planned within a strategic framework which will align technical services to organization goals. This will give a rational basis to a technical evolution. Thus, new services will be added and enhanced to achieve the agreed upon goals in shorter time.

The plan is thus viewed as both a vision of how health telematics can be used to help achieve the *HfA* goals as well as a series of steps to attain these goals. The steps must become projects in order to be accomplished systematically.

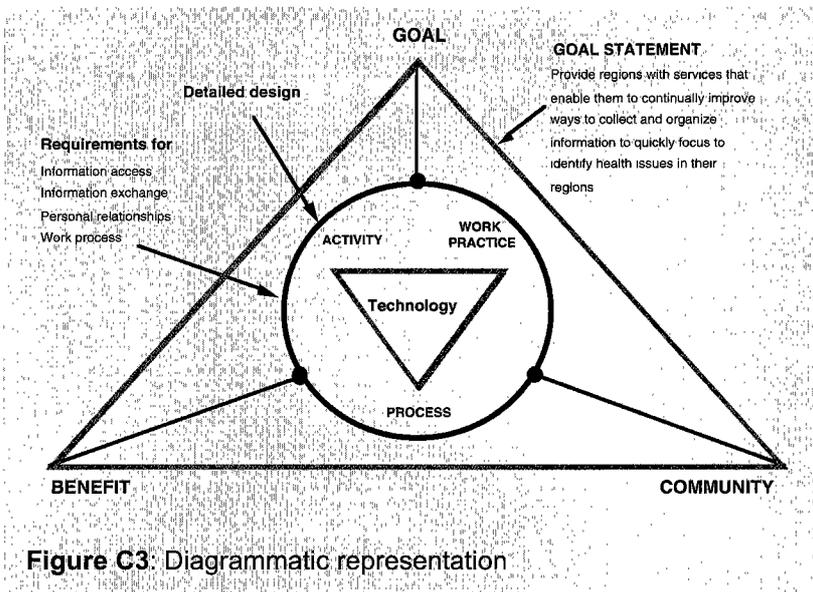
### 4.2 Developing a technological strategy

The major dimensions involved in determining a health telematics strategy are illustrated in **Figure C. 2**. Each of the boxes represents a set of issues that must be resolved during the systematic development of a strategy. It begins with an agreement on the overall WHO goals, followed by resolving what processes must be supported to achieve these goals. The activities required to realize the process must then be identified. A more detailed analysis of ways to improve work practices within each activity is the carried out and technologies are suggested to lead to improved work practices. The process can be formally enhanced by a systematic identification and resolution of specific issues.

A gradual and systematic reduction of “high” level goals down to a technical structure is illustrated by the external and internal triangles in **Figure C.3**. The overriding objective is the integration of the goals, the community and the expected improvements as illustrated by the three apexes also shown in **Figure C.2**. This results in many goal statements which define the goal, the community it will benefit and the expected outcome. For example, “Provide regions with services that enable them to continually improve ways to collect and organize relevant information in order to quickly identify important



**Figure C.2:** The planning dimensions: Viewing “health research planning” as a cooperative business process [22,3]



**Figure C3:** Diagrammatic representation

health problems” specifies ‘region’ as the community, ‘quicker identification’ as the benefit, and ‘identify important health problems’ as the goal. Such statements become the driving factors for the next level.

The next level, shown as the inner triangle, determines the process to be followed in achieving the goal, and describes it in terms of work practices that are to be followed during various process activities. The technology to support these work practices is then defined.

#### 4.2.1 Infrastructure framework

The infrastructure is seen in terms of the levels shown in **Figure C.4**. The first level consists of the telecommunication framework that exists in a country. The second level is the networking technologies which will utilize the telecommunications facilities for communication. There exists a large variety of such facilities, including not only basic facilities such as e-mail or video conferencing but also including the World Wide Web (WWW) and LOTUS Notes, as well as widely available systems often provided free of charge on the WWW, such as discussion forums. Work practices often require a number of such technologies to be chosen for integration into working systems.

#### 4.2.2 Service classes

A further distinction can be made when choosing technologies to provide the *value-added services*. Three broad types of communication classes are mentioned:

- access to information: providing easy access to reference information; this feature can be added to existing databases;
- information exchange: where information in the form of documents is exchanged between people or made available for their use. This can include meetings, distribution of messages, publishing of information;

It is now useful to conceptualize a framework for a technological strategy. Such a strategy could be seen as a basis for providing services to support work practices. It is defined in terms of two dimensions: the overall framework and the class of service.

It is possible that each region or area of strength, such as IRENEs or designated research centers, could select its own network technologies to support its work practices. This could lead to considerable duplication, however, as well as difficulties in the integration of regions for the purpose of exchanging information.

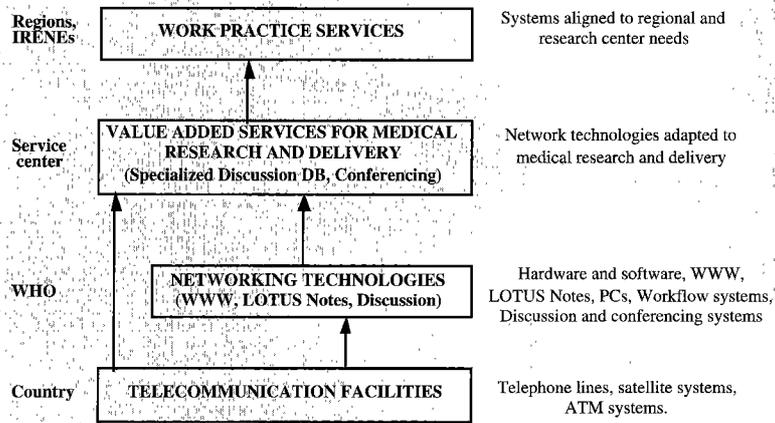
There are additional advantages in providing a further level, here called *value-added services* which specially adapt networking technologies to medical needs in ways that can be easily customized to work practices at regional levels. Modules can be “reused” at regions and IRENEs leading to reduced development costs as well as a better integration between the regions.

- interpersonal relationships: where specific individuals communicate spontaneously with each other to discuss and perhaps decide on actions to be taken, as for example, in situations where wide expert advice must be sought to make a decision, and
- work processes: that define the flow of work through the organization, usually related to projects with specific goals.

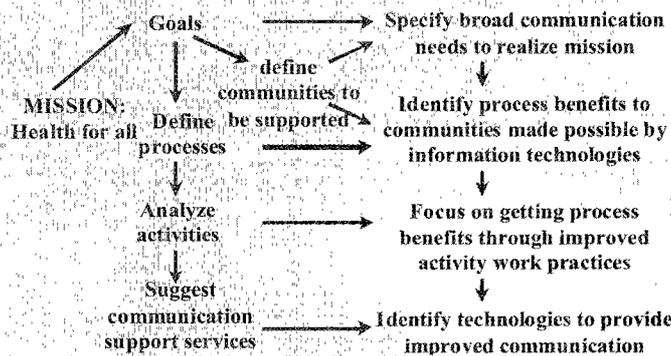
Such a classification approach is useful because different technologies are needed for each of the dif-

ferent classes. It is necessary to define the critical communication needs in terms of these broad categories [26]. This can then be followed by an initial proposal for broad technical platforms, making distinctions between core technologies such as the World Wide Web (WWW) and LOTUS Notes.

In **Figure C.3** we outlined the planning process. The detailed steps in this process are described below in **Figure C.5**.



**Figure C.4:** Infrastructure levels



**Figure C.5:** Steps in defining the strategy

	GOAL	BROAD COMMUNICATION NEED
Planning	Continuously identify world health issues	Improved collection of information at regional level, Quicker agreement and commitment on plans within ACHR, Improved awareness of issue to research community, Continuous awareness of current status
	Encourage researchers to cooperate on solving world problems	Improve ways to exchange knowledge, Provide easier access to researchers, Raise awareness of global research needs, Interfaces to stakeholders to obtain feedback and agreement, Quicker agreement and focusing on objectives, Better focusing on problems by researchers
	Develop areas of strength	Facilitate coordination between research centers, Raise awareness of research opportunities, Support for joint projects
Delivery	Eliminate a health problem and solve critical problems	Quicker availability of possible solutions to regions, Better tracking of actions that lead to the best outcomes, Raising public awareness about health problem, Improved identification, isolation and notification of problem to reduce exposure to risk, Easier access to expert teams

**Figure C.6:** Defining goals

### 4.3 A strategic analysis of the planning process

The first step is to state the goals and to define the major processes which are required to fulfill the mission. In carrying out this process of defining the required steps a number of questions must be asked.

#### 4.3.1 Planning steps

##### 1. When defining the goals -

- How does the goal lead to the realization of the mission of the *Research Policy Agenda*?
- Who are the main communities of users?
- What knowledge must be shared between communities?
- What broad communication needs are most beneficial for sharing knowledge?

##### 2. When defining the processes -

- What processes need to be followed to achieve goals?
- How can communication be used to improve processes for goal achievement?
- What are the potential benefits of communication to the selected communities?
- What activities take place in each process?

##### 3. When analyzing the activities -

- What activities are needed to implement the process?
- What work practices are followed in these activities?
- How can communication improve work practices within the activities?

##### 4. When choosing the technology -

- How can technology be used to facilitate work practices?
- What network services will provide the needed communication support?

#### 4.3.2 Identifying goals

**Figure C.6** defines potential goals and the communication needs.

#### 4.3.3 Identifying major processes

Health planning and delivery includes many interrelated processes. **Figure C.7** illustrates some of these processes. One of the major processes

includes maintaining of plans and setting of priorities. This, in turn, effects processes involving the focusing and supporting of research effort as well

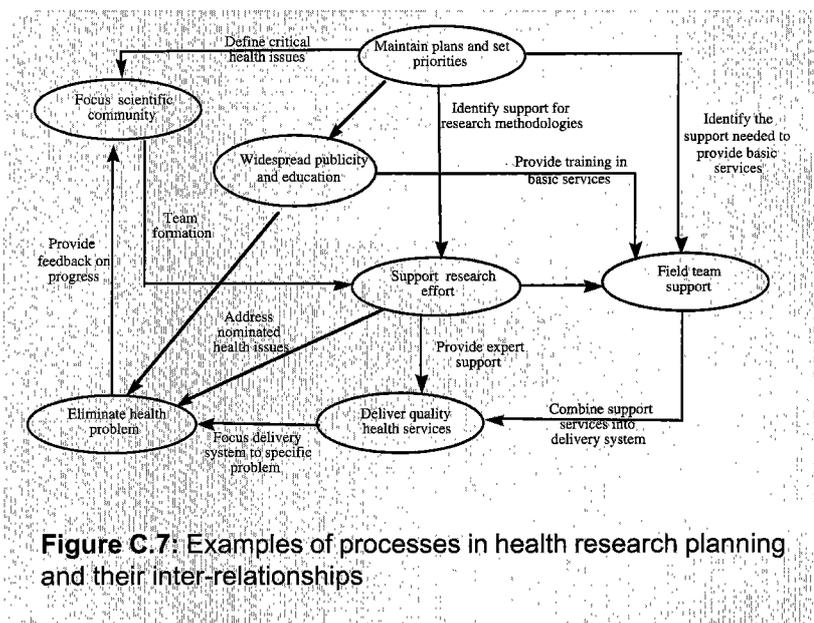
as the support of field teams. It also determines how widespread publicity and education programs are implemented and how both research and education provides support for delivering quality health.

Possible benefits achieved through each process are shown in **Figure C.8** and their relationships to the goals set by the ACHR-system are illustrated in **Figure C.9**. Processes which contribute directly to the goals are illustrated in **Figure C.8**.

### 4.3.4 Defining the activities within each process

A detailed analysis is needed to determine what happens within each process. The first step is to define the broad activities within the context of the major processes. Activities define what people do, not necessarily how they do it. Work practices define how things are done. It is particularly important to identify the more critical activities, some of which include for WHO the following:

- Getting consensus and reaching agreement
- Identifying and resolving alternatives
- Collecting and distributing information
- Focusing on issues
- Raising knowledge levels
- Raising the service quality level by improving access to current best knowledge
- Facilitating contacts
- Getting expert advice
- Supporting joint work
- Providing basic services



**Figure C.7:** Examples of processes in health research planning and their inter-relationships

Some of these activities are illustrated in **Figure C.10**. The picture is at the broad strategic level and shows the roles within the system and the high level of interactions which occurs between them:

- the **activities** as clouded images,
- the **communities** by labeled icons,
- the major **documents** or artifacts produced by the activities as rectangles.

This general approach can be used to identify major factors that influence the enterprise communication [12,32]. The different roles show how the communities with their needs can be used for identifying the benefits they can expect. These

benefits may be different for each class of role. For example, field workers may be looking for support to get access to the latest medical reports and equipment. They may also be looking for better communication inputs for their regional offices. Planners may be looking for tools that lead to better resolution of conflicts and better decisions without the need for more time-consuming meetings.

Process	Advantage (with respect to mission and goal)
FOCUS SCIENTIFIC COMMUNITY	<ul style="list-style-type: none"> <li>Better facilities to distribute information about health problem</li> <li>Improved ways for planners and experts to identify problems</li> </ul>
MAINTAIN PLANS AND SET PRIORITIES	<ul style="list-style-type: none"> <li>Planners develop higher quality plans through more expert input</li> <li>Reduced effort to planners to get information for plans</li> <li>Improved communication with regions to get universal agreement</li> <li>Easier for researchers to develop consensus on joint research</li> </ul>
DELIVER QUALITY HEALTH SERVICE	<ul style="list-style-type: none"> <li>Field workers have higher awareness of problem</li> <li>Quickly find sources of expert information needed to deliver service</li> <li>Field workers to benefit by having better facilities for their tasks</li> <li>Researchers have better access to health programs</li> </ul>
SUPPORT RESEARCH EFFORT	<ul style="list-style-type: none"> <li>Improve research focus by exchange of information by researchers</li> <li>Distribute research with effective coordination</li> <li>Researchers work on more advanced issues reducing duplication</li> </ul>
WIDESPREAD PUBLICITY AND EDUCATION	<ul style="list-style-type: none"> <li>Better access to public with most potential benefit</li> <li>Identify groups where there is lack of knowledge</li> <li>Field workers get to learn new techniques quicker</li> </ul>
TEAM SUPPORT	<ul style="list-style-type: none"> <li>Field workers aware of each others activities</li> <li>Team members informed about events requiring their attention</li> </ul>

Figure C.8: Expected process advantages

Goal	Process	Deliver quality health services	Support research effort	Widespread publicity and education
Continuously identify world health issues		<ul style="list-style-type: none"> <li>Provide feedback to planners</li> </ul>	<ul style="list-style-type: none"> <li>Identify knowledge about issues</li> <li>Monitor progress</li> </ul>	<ul style="list-style-type: none"> <li>Obtain public support</li> <li>Raise awareness of world problems</li> <li>Publicize plans and decisions</li> <li>Monitor public reaction</li> </ul>
Encourage researchers to cooperate on solving world problems		<ul style="list-style-type: none"> <li>Encourage comments on delivery issues</li> </ul>	<ul style="list-style-type: none"> <li>Support for joint research work</li> </ul>	<ul style="list-style-type: none"> <li>Encourage contribution to educational programs</li> </ul>
Develop areas of strength			<ul style="list-style-type: none"> <li>Facilitate sharing of knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Obtain contribution to educational programs</li> </ul>
Eliminate a health problem and solve critical problems		<ul style="list-style-type: none"> <li>Ensure correct solution is delivered</li> <li>Get expert advice</li> <li>Ensure correct solution is delivered</li> </ul>	<ul style="list-style-type: none"> <li>Support exchange of knowledge on health problems</li> <li>Quickly obtain relevant knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Raise awareness of problem in community</li> <li>Monitor public reaction</li> </ul>

Figure C.9: Identifying processes.

### 4.3.5 Identifying the broad communication needs

The definition of detailed needs requires the examination of the work practices within each activity and deciding on the communications support required to improve them. The next step will be to identify the broad communication needs for each of these activities. The completion of a number of

such tasks for different requirements will necessitate considerable work [28]. Once the appropriate platforms and technological strategies are known, more analysis is needed to determine how to integrate them into a platform [15,16,17].

## 4.4 Elaborating a technological strategy

A strategic analysis should identify alternatives. This framework provides guidelines for developing such alternatives [18]. The alternatives can be obtained by choosing the following:

- The systems that will provide value-added services, and
- Organizational responsibilities for developing, adapting and integrating these services.

Choosing the systems can be done by selecting the following:

- Grouping activities with similar communication classes which provide value-added services, or
- Defining the services needed to support a chosen process.

### 4.4.1 Alternatives for grouping communication classes

**Figure C.11** defines a strategic alternative where basic network technologies are grouped into value-added services that can then generate applications. It identifies three subsystems - a contact system both for getting access to experts as well as getting access to published data. A set of broad scenarios are also shown to indicate how the system would be used.

A number of such conceptual solutions can be developed depending on the priorities which are set

for the organization. Each of these could provide a different set of services aimed at specific applications. Each of these must be carefully costed and scenarios developed to illustrate how they could work and how commitment from users can be reached. Such scenarios could be developed at the regional levels to indicate the alternatives for each region, with the goal of making the value-added services adaptable to these scenarios.

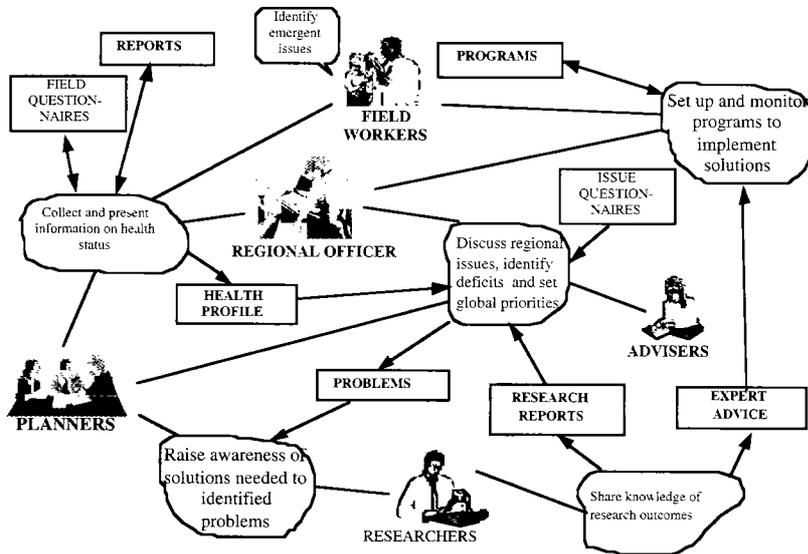


Figure C.10: Representing the activities

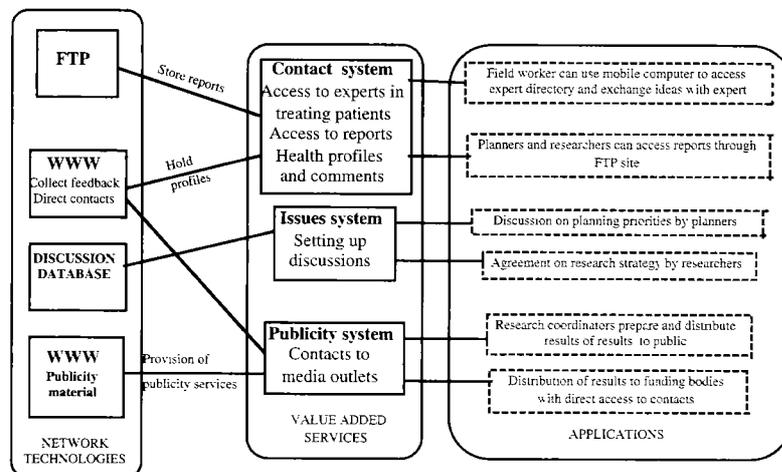


Figure C.11: An example of a strategic solution

#### 4.4.2 An example - The issues system

The issues system is one example of value-added services, where the goal is to develop a set of modules to support a variety of discussion systems. Here there may be a local concern with the difficulty

of getting medical instruments into a location. This becomes a regional issue if the problem occurs at other locations too. In this case, it is raised for discussion at the regional level and then, if deemed

significant enough, it is elevated for consideration at the global level.

There are additional scenarios for other types of discussion which require other modules. These include such tasks as focusing communities on issues, deciding on alternatives, agreeing to plans

#### 4.4.3 Organizational strategy

Because of the wide range of activities expected to be identified, a variety of technologies will be needed and considerable emphasis will have to be placed on the integration of technologies into a uniform platform. Therefore, integration will be needed for the document system, the discussion about the documents and for the distribution system.

The systems will then be placed in a variety of locations and organizational units. Possible organizational units are illustrated in **Figure C.12**. These include:

- WHO offices which plan, coordinate and monitor the activities,
- Regional centers for local coordination and information distribution,
- Areas of strength both located in a physical center, or in distributed virtual centers,
- Existing centers of learning for providing information about specific topics, and
- A service center that coordinates the provision of technology support services to centers.

Each of these units can be designated by WHO. For example, Planet HERES provides one such service for the support of priority setting containing a module for comment collection as well as other services. The analysis used to determine the platform for this activity [17] would be needed for all of the other proposed activities.

etc. These can be constructed using the basic modules with additional modules added for structuring and evaluating the alternatives. An effective issue system would be customized in the sense that users can set up networks of discussions that address specific issues within accepted organizational reporting and cultural norms.

The introduction of value-added services is based on the idea of seeding with subsequent responsibility then delegated to regions. The proposed steps are to introduce individual services to regions for use in specific programs. The first step will be to introduce the contact service, which is currently a mature prototype. It can be introduced on short notice. This will be followed by the introduction of publicity and issues services. After introduction and initial experimentation, it is proposed that the first IRENE will be introduced where services will be integrated to support specific center operations. It is suggested that a two year seeding period, to be coordinated by a central service center, be funded prior to a distribution of the process to the regions. There is still development necessary to fine tune the systems. The introduction phase will include the first IRENE and then pass the lessons learned from this to regions through a workshop at the beginning of the second year. Funding for the seeding period for the introduction of the value-added services is a small sum compared to the cost of the overall development of networking technologies. It is expected that many of the value-added services will be provided through research efforts at partner institutions.

It may be appropriate to suggest that regional offices nominate regional coordinators. A workshop could be held for the first IRENE to make the coordinators aware both of the technical aspects of the services as well as the social implications of the new approach.

## 4.5 Implementing the health telematics strategy

Making health telematics available will, however, not guarantee its effective utilization. Most enterprises have found that intended users are often too busy in their own work to take enough time off from their work to undertake the necessary training. It is thus recommended that special personnel and specific programs should be developed to assist new users to become familiar with the technologies. Such personnel will be responsible for setting up the equipment, introducing it to the users, and exploring new ways for integrating the new technologies into existing work practices.

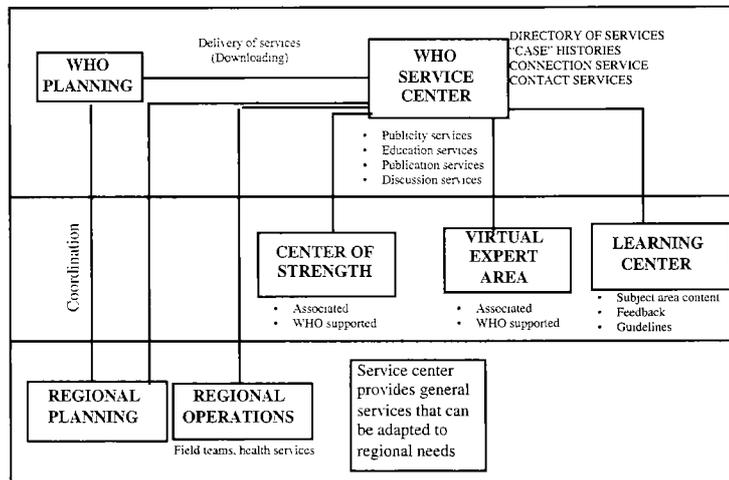


Figure C.12: Responsibility for system delivery

### 4.5.1 Developing health telematics services for focusing on research issues

An important goal is to make communities aware of global health research issues. Support systems to be provided for this purpose include:

- A distribution system for research planners to construct a set of relevant documents and references,
- A contact systems that includes a set of profiles for research planners to identify those scientists around the world who are most likely to be interested in specific topics,
- A discussion system for planners (or the region, if the issue impinges on a particular region) to collect responses to regarding selected health research issues. The discussion system is integrated with the distribution system to make it easy to relate comments to published data.

The proposed support system would, of course, also be associated with informal contacts through meetings and linked to scientific conferences and meetings.

Such services have been described earlier [15]. They focus on integrating information exchange through telematics-based discussion systems. Value-added systems can also support various issue scenarios such as the one described here to focus on agreement on action or to make a decision along organizational lines.

Other scenarios can also be supported in this way. For example, once agreement is reached that there is a need for joint research; services could be provided in the following manner:

- Experts use directory services to find other experts with similar interests while using WWW publications from ACHR to determine research needs,
- The experts set up a private discussion system to explore various approaches and contributions,

- Agreeing on the research programs following the discussion,
- The research work is set up and monitored by a tracking system.

This kind of software development processes are described in [13,21].

#### 4.5.2 Developing and sharing value-added services

Many of the services needed by health workers are generic. Therefore, it is important to set up a center that will provide generic services which can then be customized to regional needs. This has both the advantage of sharing expertise and providing standards where information from various regions can be easily integrated for use in global decision making.

A technical services center should be nominated to develop the value-added services and to define ways of distributing them. The services should promote:

- Distribution of knowledge to WHO personnel with notification parameters (agents) based on profiles to monitor developments,
- Distribution of knowledge to the public,
- Development of services to support centers such as shown in **Figure C.12**,
- Support of global planning.

#### 4.5.3 Establishing knowledge and learning centers

A learning center becomes a repository of information and knowledge in an area. It includes references to particular field of health. This may include:

- Services for dissemination of information to the public and other interested parties,
- Feedback and answers to specific questions.

Such centers could be associated with areas of strength or with established educational institutions. At the same, time such a center could support the

development of knowledge through provision of services to:

- Support content development in a variety of subject areas,
- Support the distribution of content material,
- Combine knowledge in a way that it addresses new specialized needs and services
- Provision of feedback and support facilities to users.

## 5 Conclusion

Having described the role of health telematics in the global health research process, the authors conclude that the implementation of health telematics in the global research process is urgently necessary. While the potential hazards in the application of computer-based technologies like health telematics are great, especially in conducting research across international borders, there are even greater opportunities to make a significant difference to the health status of developing nations. The overall goal of WHO to narrow the gap between North and South could be realized if health telematics, by way of processes like Planet HERES and IRENES, is applied effectively.

This paper also described a framework for systematically developing a strategy for introducing health telematics within a national or regional health organization. It suggested that a gradual evolution is necessary, given both the complexity of introducing integrated systems, and the ability of people to fully utilize them. The proposed process begins with defining the goals to implement the Research Policy Agenda. Business processes to realize these goals are identified, followed by defining the activities in the processes. Particular attention was paid to identifying the communication needs of these activities, which were, in turn, used to define the strategy.

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