Integrated assessment and management of health care infrastructure and technology

Dr Louwrence Erasmus, Mladen Poluta and Dr Richard Weeks

In many countries, large numbers of people suffer because they cannot access the necessary health care, while the cost of health services annually pushes 100 million people worldwide into poverty, according to a report by the World Health Organization (WHO).

It is universally accepted that all people should have access to the health care they need. However, health care inflation is rising worldwide and countries are continually seeking more funds for health care. Richer countries are struggling to keep up with the rising costs of technological advances and the increasing health demands of their ageing populations, while low-income countries are often resource poor and cannot ensure access to even basic health care services.

There are wide variations in the coverage of essential health care services within countries and even between countries. Unfortunately, amid the rising global demand for essential health care services, 20 to 40% of the resources spent on health care globally are wasted. Common causes of inefficiencies include demotivated health workers, the duplication of services and the inappropriate or overuse of medicines and technologies.

According to *The World Health Report* of the WHO, published in 2006, in Africa 3% of the world's health care workers combat 24% of the global disease burden with less than 1% of the global health expenditure.

Health care in South Africa

In many respects, the health care problems South Africa faces are not different from those experienced globally. In this country, health care services have to be delivered in a resource-scarce environment. Money should not be regarded as a resource, but as a means to acquire resources. The incorrect perception of money as a resource results in the wrong value systems being used for decision-making.

The South African National Department of Health (NDOH) has adopted the following vision for its Human Resources for Health Strategy for 2012: "A workforce developed through innovative education and training strategies and fit for purpose to meet the needs of the re-engineered health system and to measurably improve access to quality health care for all."

In support of this vision, the Minister of Health has signed a national service delivery agreement with the President of South Africa for a "long and healthy life for all South Africans". In this agreement, the Minister and the NDOH commit to the following strategic outputs that the health sector must achieve:

- Increased life expectancy
- Decreased maternal and child mortality
- Combating HIV and Aids and decreasing the burden of disease from tuberculosis
- Strengthened health system effectiveness

To address these priorities, the Minister of Health, in his budget speech in May 2011, announced the re-engineering of the primary health care (PHC) system and the overhaul of the health system. The Minister announced that PHC re-engineering will concentrate on the prevention of disease and the promotion of health. The PHC system will be located in a district-based service delivery model, focusing especially on maternal and child mortality. The Minister has stated that the improved management of health care institutions and health districts will be essential to facilitate the re-engineering of PHC. The commissioning of five flagship academic hospitals was announced as part of the process to re-engineer and strengthen the health system and develop a balanced capacity for health care delivery.
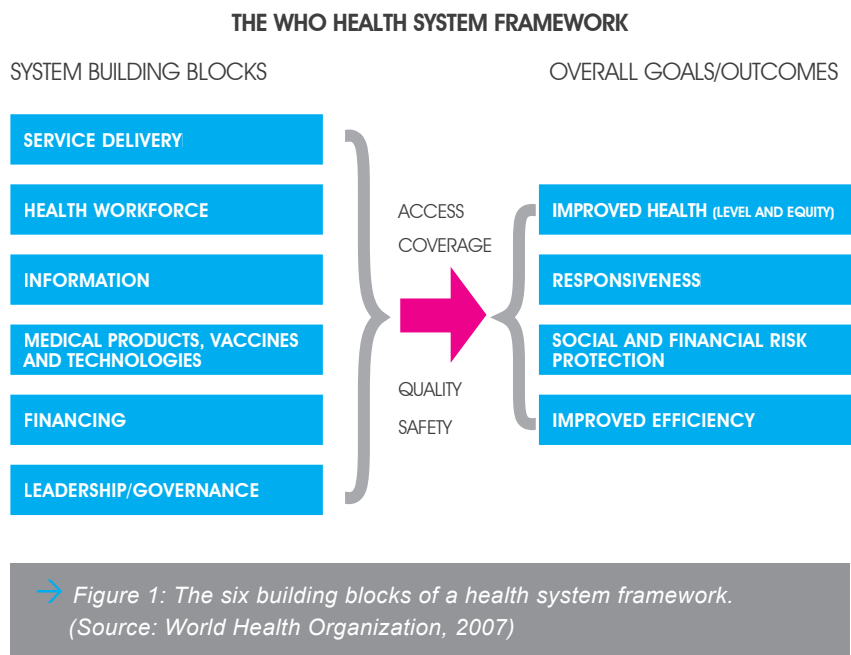
In support of the re-engineering of PHC and the overall health system, National Health Insurance (NHI) was announced and made policy in 2011, with the piloting of the programme in April 2012. The first five years of the NHI will focus on strengthening the health system in the following areas:

- Management of health facilities and health districts
- Quality improvement
- Infrastructure development
- Medical devices, including equipment
- Human resources planning, development and management
- Information management and systems support
- Establishment of the NHI Fund

Quality of health care

In 2001, the Committee on Quality of Health Care in America of the Institute of Medicine of the National Academies proposed six quality criteria for 21st-century health care systems in its report *Crossing the quality chasm: A new health system for the 21st century*.

Health care systems should be *safe* (avoid injury to patients from the care that is intended to help them), *effective* (provide services based on scientific knowledge to all who could benefit and refrain from providing services to those not likely to benefit), *patient-centred* (provide care that is respectful of and responsive to individual patient preferences, needs and values, and ensure that patient values guide all clinical decisions), *timely* (reduce waiting periods and sometimes

THE WHO HEALTH SYSTEM FRAMEWORK

SYSTEM BUILDING BLOCKS   OVERALL GOALS/OUTCOMES

→ *Figure 1: The six building blocks of a health system framework. (Source: World Health Organization, 2007)*

harmful delays for both those who receive and those who give care), *efficient* (avoid waste, including waste of equipment, supplies, ideas and energy) and *equitable* (provide care that does not vary in quality because of personal characteristics, such as gender, ethnicity, geographic location and socioeconomic status).

In evaluating the NHI areas that require strengthening and these six quality aims, the complexity of the subject begins to emerge. Overlap exists between the different areas associated with the NHI without the ontology to treat each independently.

Health care infrastructure and technology

Health care infrastructure and technology (HIT) are important and integral components of the health

care service delivery system. The physical environments in which health services are rendered are constituted by HIT. Quality services can only be provided when physical facilities, installations and equipment are in good working condition to provide a fully functional and operational environment.

Infrastructure and technology make up the visible interface between health departments and the public at large, and it is important that their quality, condition and cleanliness reflect the high standards set by health departments for the provision of health services to a country's people. A clear distinction needs to be made between health care infrastructure and technology.

Health care infrastructure comprises physical infrastructure (buildings, installations, energy sources, water and gas supplies) and logistics and support systems (supply systems, communication, information and transport systems, and waste disposal systems).
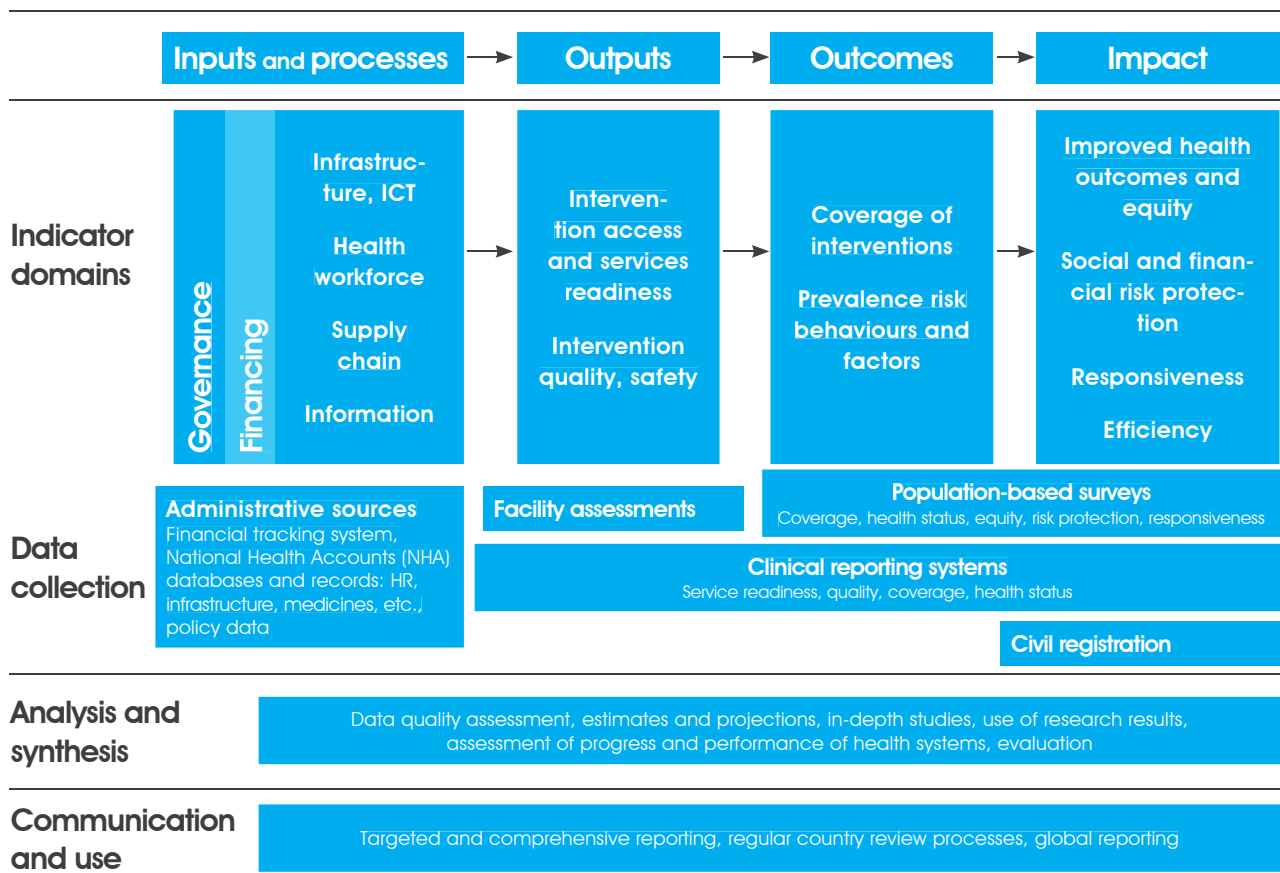
Health care systems should be safe, effective, patient-centred, timely, efficient and equitable.

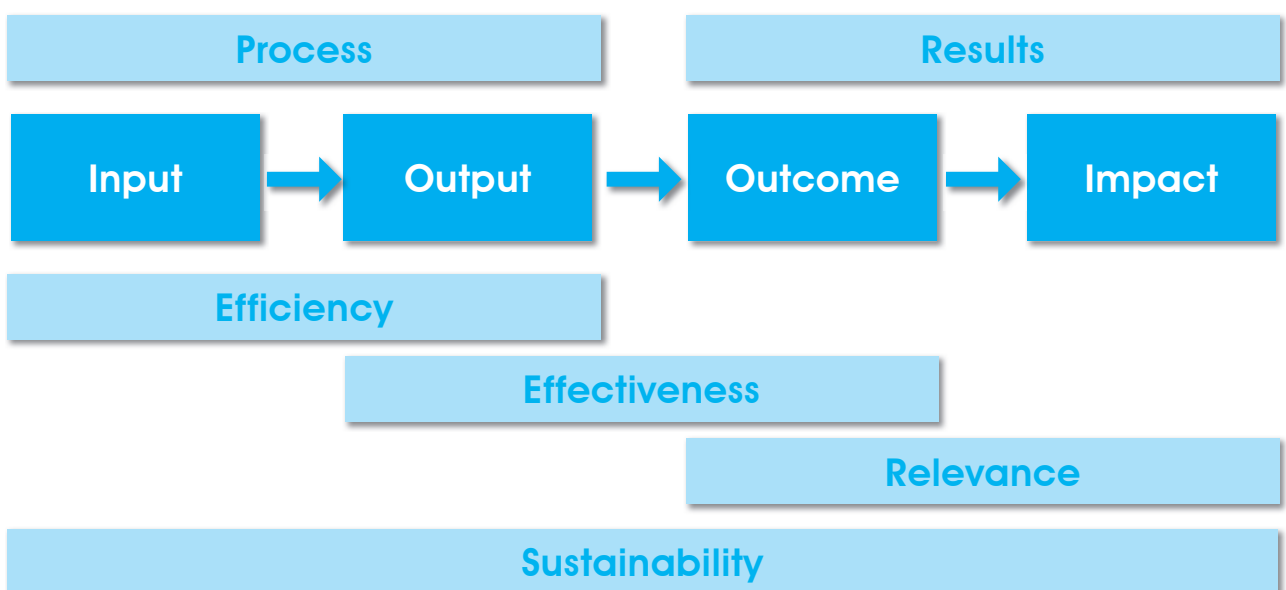## Information requirements for stakeholders in health care systems

Stakeholder	Examples of needs	Data requirements
Government	- Monitoring the health of the nation - Setting health policy - Ensuring that regulatory procedures are working properly - Ensuring that government finances are used as intended - Ensuring that appropriate information and research functions are undertaken - Monitoring regulatory effectiveness and efficiency	- Information on performance at national and international levels - Information on access and equity of care - Information on utilisation of service and waiting times - Population health data
Regulators	- Protecting patients' safety and welfare - Ensuring broader consumer protection - Ensuring that the market is functioning efficiently	- Timely, reliable and continuous information on patient safety and welfare - Information on probity and efficiency of financial flows
Payers (taxpayers and members of insurance funds)	- Ensuring money is being spent effectively, efficiently and in line with expectations	- Aggregate, comparative performance measures - Information on productivity and cost-effectiveness - Information on access to (and equity of) care
Purchaser organisations	- Ensuring that contracts offered to their patients are in line with the objectives the patients expect	- Information on patient experiences and patient satisfaction - Information on provider performance - Information on the cost-effectiveness of treatments
Provider organisations	- Monitoring and improving existing services - Assessing local needs	- Aggregated clinical performance data - Information on patient experiences and patient satisfaction - Information on access and equity of care - Information on utilisation of service and waiting times
Physicians	- Staying up-to-date with current practice - Being able to improve performance	- Information on current practice and best practice - Performance information benchmarks
Patients	- Being able to make a choice of provider when in need - Information on alternative treatments	- Information on location and quality of nearby emergency health services - Information on quality of options for elective care
The public	- Being reassured that appropriate services will be available if needed in the future - Holding government and other elected officials to account	- Broad trends in, and comparisons of, system performance at national and local level - Efficiency information - Safety information

In many respects, the health care problems South Africa faces are not different from those experienced globally. In this country, health care services have to be delivered in a resource-scarce environment.

	Inputs and processes →	Outputs →	Outcomes →	Impact
Indicator domains	**Governance** **Financing** **Infrastructure, ICT** **Health workforce** **Supply chain** **Information** →	**Intervention access and services readiness** **Intervention quality, safety** →	**Coverage of interventions** **Prevalence risk behaviours and factors** →	**Improved health outcomes and equity** **Social and financial risk protection** **Responsiveness** **Efficiency**
Data collection	**Administrative sources** Financial tracking system, National Health Accounts (NHA) databases and records: HR, infrastructure, medicines, etc.; policy data	**Facility assessments**	**Population-based surveys** Coverage, health status, equity, risk protection, responsiveness **Clinical reporting systems** Service readiness, quality, coverage, health status	**Civil registration**
Analysis and synthesis		Data quality assessment, estimates and projections, in-depth studies, use of research results, assessment of progress and performance of health systems, evaluation		
Communication and use		Targeted and comprehensive reporting, regular country review processes, global reporting		

→ Figure 2: Framework for monitoring and evaluating health systems strengthening. (Source: Global Fund Toolkit)

Process   **Results**

Input → **Output** → **Outcome** → **Impact**

Efficiency

Effectiveness

Relevance

Sustainability

→ Figure 3: Results-based evaluation of development intervention. (Source: Nagel & Remmelzwaal, 2010)

→ *Health care technology comprises the devices, drugs, and medical and surgical procedures used in the prevention, diagnosis and treatment of disease.*

The two components of a health care infrastructure are traditionally part of two different professional disciplines, which require different competencies, and managerial and operational skills. Health care technology comprises clinical devices and has been defined by the WHO as the devices, drugs, medical and surgical procedures – and the knowledge associated with these – used in the prevention, diagnosis and treatment of disease, as well as in rehabilitation and the organisational and supportive systems within which care is provided.

The WHO describes the health system framework as comprising of system building blocks with certain overall goals or outcomes. HIT falls under the building block 'medical products, vaccines and technologies'.

The WHO makes policies and guidelines available on a continuous basis for the planning and manage-

ment of infrastructure and technology to member states. The objective of this is to strengthen the capacity of countries to effectively acquire and manage physical health care assets to ultimately facilitate improved health service delivery by optimising the condition and sustainable use of HIT.

A framework for the monitoring and evaluation of the strengthening of health systems was developed by the Global Fund to fight Aids, tuberculosis and malaria as part of a Monitoring and Evaluation Toolkit.

A report published in 2010 by Dr Joachim Nagel and Dr Bastiaan Remmelzwaal, members of the WHO's Advisory Group on Health Technology in 2009, illustrates the relationship between the broader developmental considerations of the framework.

Nagel and Remmelzwaal point out that the definition of performance indicators for HIT is a difficult task.

A major problem is the number of cadres of health care professionals directly or indirectly involved in the many aspects of HIT. On the one end of the spectrum, the technicians and engineers are primarily interested in the tangible outputs of their efforts to acquire and effectively manage a fleet of physical assets. On the other, the interests are mainly on issues around cost-effectiveness and the sustainable impact of HIT on the health delivery system and thus on the patient. The rest falls somewhere in between the extremes and is confronted by multi- and transdisciplinary discussion.

The development of performance measurement in health care systems has rarely been pursued with the requirement of the information users in mind. Performance measurement systems have usually sought to inform a variety of users, typically presenting a wide range of data in the hope that some of the information collected will be useful to different parties. With the diverse information

needs of different stakeholders in health care systems, it is highly unlikely that a single report will be useful for everybody; thus different reports should be generated for different information users in the health care system over the same database. This is a problem that has been addressed many times in systems engineering, especially under requirements engineering, which forms part of the requirements and functional analysis.

The role and importance of HIT in the development of sustainable

it is given. There is evidence that the inappropriate management and deployment of HIT negatively affects sustainability. With adequate planning and management, rapid technology life cycles can lead to health systems that are effective, efficient, equitable and sustainable at every level. To achieve this, it is necessary to employ partnerships between the public and private sector, as well as universities and research institutions.

There is a need for better sharing in the development and use of

national, regional and district level. There is a hierarchy of management training needs in this field, and all of these warrant attention. However, the most neglected problem that should receive high priority in the overall human resource development programme is that of the provision of the education and training that is suitable for key decision-makers at national, provincial and district level. Despite the skeletal framework of a master's programme presented in 1990, no programme had been implemented internationally that was designed to meet the pressing needs of HIT. The problem may be the strictly scientific management approach suggested in the programme, while HIT is a complex adaptive system that cannot entirely be treated with archaic scientific management principles.

Health Care Infrastructure and Technology Group

With this in mind, the Graduate School of Technology Management (GSTM) at the University of Pretoria is ideally positioned to support most of the initiatives of the NDOH, with the current expertise, education and training programmes already deployed.

As a response to the South African health care challenge, the GSTM is establishing itself as the leading national, regional and global provider of integrated, comprehensive capacity-building and support in the integrated assessment, innovation and management of health care infrastructure and technology.

health systems is often not fully understood by policy- and decision-makers, planners and other health care workers, perhaps due to the shortage of documented evidence on the subject. Rapid improvements in technology further accentuate the need for the improved management of all life cycle phases of HIT to better exploit the emerging opportunities and overcome evolving problems. Despite all the accumulated knowledge on the problem and prospective solutions, the tangible progress is very small.

In a report on physical infrastructure and technology published in 1999, the WHO stressed the importance of HIT, which permeates all facets of health care delivery and provides the material framework within which

management tools and impact indicators, and pilot or demonstration projects to promote a better understanding and appreciation of the role and importance of HIT in the health sector.

Management of health and medical care support and technical services

In 1990, the WHO published a position paper to provide the necessary background for discussions around the possible development of an appropriate education strategy for the management of medical technologies.

One aspect of the management problem is the lack of leadership at

The GSTM has leading experts in the areas of technology and innovation management, project management, engineering services management, asset management, sustainable life cycle management and systems engineering, as well as value-added expertise from newly appointed assessment, innovation and management (AIM) HIT expert networks.

The GSTM's services model (based on systems thinking and complex adaptive system principles) can assist, in particular, to address the six priority areas set out by the Minister of Health: the values

and attitudes of staff, a reduction in waiting time, cleanliness and hygiene, patient safety, clinical care and governance, infection prevention and control, and the availability of basic medicines and supplies.

As a response to the South African health care challenge, the University of Pretoria – through the GSTM – is establishing itself as the leading national, regional and global provider of integrated, comprehensive capacity-building and support in the integrated assessment, innovation and management (iAIM) of health care infrastructure and technology, with a non-exclusive focus on resource-scarce health care environments and the African region in particular. The capacity-building and support activities will be driven by the needs of clients and will, in turn, be supported by a dynamic and responsive research programme underpinned by values of excellence, relevance and impact.

The iAIM-HIT programme is uniquely positioned to contribute to six of the seven listed NHI areas by optimally utilising current research, academic and further education offerings in the GSTM, the School of Engineering and the School for the Built Environment in the Faculty of Engineering, Built Environment and Information Technology, as well as the School for Health Systems and Public Health in the Faculty of Health Sciences at the University of Pretoria. Focus areas for the iAIM-HIT programme include the following:

- Responsible and sustainable management of public sector health care physical assets, with a focus on resource-scarce health care environments in the African region
- Supporting – through applied research and targeted capacity-building – the South African departments of Health and

→ The iAIM-HIT programme positions itself to meet the current and future needs of clients in both the public and private sector.

Public Works in addressing the challenges associated with the emerging NHI system and the associated effectiveness, efficiency and quality of health care delivery
- Developing HIT-related decision support tools and 'lean' management information systems
- The application of systems thinking and operational research methodologies to health care delivery and related managerial and technology interventions
- The optimisation of the health care technology innovation and technology transfer process
- Developing innovative engineering and architectural approaches to airborne infection control and related capacity-building
- Developing and strengthening health care engineering in the African region

The iAIM-HIT programme positions itself to meet the current and anticipated future needs of clients in both the public and private sector by building cadres of competent practitioners, managers and leaders

in the broad area of iAIM-HIT. In the programme's commitment to assist and support the development of a long-term training and capacity-building strategy for the health care infrastructure and technology sector in South Africa, it is also realised that resources are scarce and should not be wasted. Therefore, based on the principles of efficiency and sustainability, it is essential not to duplicate what is already available. This led to the iAIM-HIT programme taking a strategic decision, in consultation with partners at the universities of KwaZulu-Natal and Cape Town (UCT), to enter the e-health-related capacity-building space. To this end, a draft proposal for a National Centre for e-Health Studies (NCeHS) has been formulated. The vision is that the NCeHS will fulfil the following functions:

- Establish and maintain the national reference model for e-health, based on services science principles
- Create a framework in which stakeholders understand their roles and responsibilities for the e-health studies process to

The broad area of e-health includes the established areas of telemedicine and tele-education, as well as the emerging potential of mobile health.

make optimal use of national resources
• Support an inter- and transdisciplinary research strategy for e-health studies in South Africa and beyond
• Support a human capacity-building strategy for e-health in the public health sector
• Facilitate the exchange of experience and expertise between institutions to maximise national assets for research and human capacity-building in e-health studies
• Define a set of metrics that will measure progress towards the goals of the e-health studies programme
• Assess national and international e-health development trends on an ongoing basis for impact in the NCeHS
• Maintain close ties with all major stakeholders, notably and especially the national and provincial departments of Health

As part of its mandate, the NCeHS will also address integrated planning, appropriate innovation, proper assessment, informed acquisition and the efficient management of ICT for e-health. The broad area of e-health includes the established areas of telemedicine and tele-education, as well as the emerging potential of mobile health (m-health), focusing on the use of mobile technologies, such as cellphones and tablets.

Further opportunities are explored with various schools and departments at the University of Pretoria, the Health Care Technology Management programme at UCT, the Telehealth Department at the University of KwaZulu-Natal, other national and international academic institutions, various national research councils and industry partners. ❸

Dr Louwrence Erasmus, Mladen Poluta and Dr Richard Weeks are associated with the Department of Engineering and Technology Management at the Graduate School of Technology Management (GSTM). Dr Erasmus specialises in sustainable life cycles, systems engineering, and health care infrastructure and technology. Dr Weeks specialises in engineering service science management. Poluta established the Health Care Technology Management (HTM) Programme at the University of Cape Town in 1999. This was the only one of its kind in Africa. He is part of the team that is establishing a comprehensive programme to address the integrated assessment, innovation and management of health care infrastructure and technology at the GSTM.

References

1. Committee on Quality of Health Care in America, Institute of Medicine. 2001. *Crossing the quality chasm: A new health system for the 21st century.* The National Academies Press.

2. Erasmus, L & Doeben-Henisch, G. 2011. *A theory for the systems engineering process.* Africon 2011. Livingston, Zambia: IEEE.

3. Human Resources for Health South Africa (HRH SA). 2012. *The HRH Strategy for the health sector.* HRH SA: 2012/13–2016/17.

4. Nagel, J & Remmelzwaal, B. 2010. *Strenghtening healthcare infrastructure and technology management for optimized health service delivery.* Luxemburg Development: WHO Project Technical Document.

5. Remmelzwaal, B. 2006. Evaluation of UNICEF crisis response in various countries. Unpublished.

6. Smith, P, Mossialos, E & Papanicolas, I. 2012. Performance measurement for health system improvement: Experiences, challenges and prospects. In: *Health systems, health, wealth and societal well-being – Assessing the case for investing in health systems* (pp. 247–280). Edited by J Figueras and M McKee. Open UniversityPress: McGraw-Hill Education.

7. World Health Organization. 1990. *Position Paper: Proposal to establish an international school for the management of health and medical care support and technical services.* Geneva: WHO-EURO Ref. ICP/PHC 698.

8. World Health Organization. 1999. *Consultation on physical infrastructure and technology.* Draft final report. Geneva: WHO.

9. World Health Organization. 2006. *The World Health Report.* Geneva: WHO.

10. World Health Organization. 2007. *Everybody's business. Strengthening health systems to improve health outcomes.* Geneva: WHO's Framework for Action.

11. World Health Organization. 2012a. 10 facts on universal health coverage. Available: http://www.who.int/features/factfiles/universal_health_coverage/en/ (accessed on 14 June 2012).

12. World Health Organization. 2012b. Health financing for universal coverage. Available: http://www.who.int/health_financing/en/index.html (accessed on 14 June 2012).