Managing the Import and Use of Healthcare Technology in Sub-Saharan Africa

Thesis

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Managing the Import and Use of Healthcare Technology in Sub-Saharan Africa

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Dedicated To:

My Dad

Who was an engineer all along and I was too young to realize;
with whom I never got the chance to discuss the delights of engineering.

1917 – 1970

My Uncle

Who became an engineer the hard way, up from the shopfloor.
From an era that frowned on women engineers, he came around to
enjoying many a discussion on engineering problems with me.

1922 – 2002

All Women Engineers

May they bring a different perspective.

and to

My Beautiful Son

Only his good-natured and patient spirit
allowed me to finish this whilst he was so young.
May he be .... what ever he wants to be.

2003 –

CONTENTS

Abstract

This Thesis investigates the import and use of healthcare technology into Sub-Saharan Africa. With the increasing range of equipment types present in the health sector, the effective management of technology is of growing importance if health services are to improve in developing countries. Yet this sector has been relatively neglected within the traditional technology transfer, management, and development literature.

The activities and players involved in the healthcare technology sector are complex, thus an holistic healthcare technology package system is identified, and theoretically and practically assessed as a modelling framework. This tool is applied to provide detailed analysis in three case study countries over time – Zambia in 1990, Botswana in 1992, and Namibia in 1997, with a documented learning process.

The key issue pursued is how to improve the sustainability of healthcare technology. This proves fundamentally to be a management issue, and five overarching key constraints emerge:-

* the institutional framework available for delivering healthcare technology management throughout a country;
* training personnel and developing a national technical management capacity;
* sufficient allocation of financial resources;
* technical support availability from the private sector;
* the role played by external support agencies.

These five issues are studied in detail with support from relevant literature. The research proves that it is necessary to approach the subject from three perspectives. Thus a Thesis framework is used which ensures that healthcare technology is analysed as a *Technological Systems* issue, an *Institutional Organization* issue, and a *Development* issue. The area of overlap between these perspectives is key to finding creative solutions for sustainability.

The conclusions show that cross-denominational strategies will be essential between health service providers, the national support environment, donors agencies, the private sector, and the region. All institutions involved need to find ways to become 'learning organizations' in this field.

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Acronyms

AFTH	African Federation for Technology in Healthcare
AIDS	Acquired immune deficiency syndrome
AMMB	Association of Medical Missions of Botswana
AS/HS	Assistant Secretary, Hospital Services
BDF	Botswana Defence Force
C&G	City and Guilds
CET	Chief engineering technologist
CETW	Clinical Engineering Technical Workshop
CIM	Centrum für Internationale Migration und Entwicklung (German church organization)
CMAZ	Churches Medical Association of Zambia
CMS	Central Medical Stores
CSSD	Central Sterile Supplies Department
DABS	Department of Architecture and Building Services
DANIDA	Danish International Development Agency
DEMS	Department of Electrical and Mechanical Services
DFID	Department for International Development (of the UK)
DHCC	District Health Coordinating Committee
DOS	Department of Supply
DOW	Department of Works
ECG	Electrocardiograph
ECRI	Emergency Care Research Institute
EEC	European Economic Community
ENT	Ear, nose, and throat
EPI	Extended programme of immunization
EU	European Union
FINNIDA	Finnish International Development Agency
GDP	Gross domestic product
GEC	General Electric Company
GNP	Gross national product
GRZ	Government of the Republic of Zambia
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German government agency for technical assistance)
HIV	Human immunodeficiency virus
HRD	Human Resource Development
HTP	Healthcare Technology Package
HTS	Healthcare Technical Service
ICU	Intensive care unit
ILO	International Labour Organization
IMF	International Monetary Fund
IT	Institutional training (component of trade testing courses)
JICA	Japanese International Cooperation Agency
LDCs	Least developed countries
MEMS	Medical Equipment and Maintenance Services
MET	Medical and Education Trust
MFDP	Ministry of Finance and Development Planning
MFED	Ministry of Finance and Economic Development
MINSA	Ministerio de Salud

MLGL&H	Ministry of Local Government, Lands, and Housing
MNC	Multi-national corporation
MOF	Ministry of Finance
MOH	Ministry of Health
MOHSS	Ministry of Health and Social Services
MOW	Ministry of Works
MOWTC	Ministry of Works, Transport, and Communication
MSIEC	Medical and Surgical Instruments and Equipment Committee
MTTC	Madirelo Training and Testing Centre
NABAIT	National Advisory Board for Apprenticeship and Industrial Training
NDP	National Development Plan
NGO	Non-governmental organization
NHI	National Health Institute
NORAD	Norwegian Agency for Development
ODA	Overseas Development Agency (of the UK) – became DFID
OECD	Organization for Economic Cooperation and Development
p.a	Per annum
P&P	Permanent and pensionable
PAHO	Pan-American Health Organization
PAM	Physical assets management
PHCS	Primary Health Care Services
PPM	Planned preventive maintenance
PSC	Public Service Commission
PWD	Public Works Department
R&D	Research and development
R,D&D	Research, development, and design
RHMT	Regional Health Management Team
S&T	Scientific and technical
SA	South Africa
SIP	Sector investment programmes
SITC	Standard International Trade Classification
SMET	Senior medical equipment technician
SSA	Sub-Saharan Africa
SWAP	Sector wide approach
TSS	Technical Support Services
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development..
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
US	United States (of America)
USAID	United States Agency for International Development
US$	United States dollar
UTH	University Teaching Hospital
VET	Vocational education and training
VTC	Vocational Training Centre
WCH	Windhoek Central Hospital
WHC	Windhoek Hospital Complex
WHO	World Health Organization
ZCCM	Zambia Consolidated Copper Mines

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CHAPTER ONE: INTRODUCTION AND OVERVIEW

1.1 AIM OF THE THESIS

1.1.1 Overview

The story of this Thesis started in 1988 when I published a generic modelling framework for studying the healthcare technology sector within any country. It was a system called the Healthcare Technology Package (HTP)[a]. It identified 19 sub-systems: 11 components to analyze within the healthcare technology sector, four categories of 'players' involved in the sector to investigate, and four study areas to provide background context. I used this modelling framework over many years undertaking consultancy and research work in developing countries. In particular, I used it in three country case studies which represent the field work for this Thesis – Zambia in 1990, Botswana in 1992, and Namibia in 1997. The case studies investigate the situation facing healthcare technology within the health service of developing countries in Sub-Saharan Africa (SSA)[b], concentrating predominantly on the public sector but also looking at the private and independent sectors for comparison.

These case studies produced many findings concerning each sub-system of the HTP system. From the research, a perception grew that there are five fundamental overarching themes that occur repeatedly. An understanding of these themes is required to appreciate the constraints to progress with healthcare technology in developing countries, and these themes will be the key to answering my main research question:-

"How can the sustainability of the healthcare technology sector be improved in Sub-Saharan Africa?"

My approach to this research means the Thesis pursues several aims. First, it examines the use of my modelling framework as a 'tool', and the usefulness of the vast quantities of empirical data generated for the analysis of the healthcare technology sector within any country. Second, it records the learning process involved in applying the modelling framework, and monitors the way in which this tool needed to be adapted to improve its use as the country case studies proceeded. Third, the Thesis examines how the effective management of healthcare technology requires the command of *three* perspectives – healthcare technology as a *technological system*, as an *institutional organization issue*, and as a *development issue*. This is my Thesis framework that arose from insights gained during

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a. There is an acronym list at the front of the Thesis.
b. Sub-Saharan Africa is defined as all of Africa excluding Algeria, Egypt, Libya, Morocco, and Tunisia; and before 1994 also excluded South Africa.

the research. I argue that all three perspectives must be taken into consideration at the same time, if the sector is to be effectively sustained. Thus, these perspectives help me to formulate and investigate my research questions, and explore in detail the five overarching themes identified and the effect they have on the sustainability of the healthcare technology sector.

This Thesis aims to make an important contribution to the healthcare technology field by gathering data, describing conditions in three countries in Sub-Saharan Africa over a decade, analyzing the situations found, and providing insights into possible constraints and solutions for sustainability. The *World Health Organization (WHO)* launched its Global Action Plan for healthcare technology in 1987, to raise awareness of the issues and act as an umbrella for efforts being made at national, regional, and international levels to strengthen the management and planning of healthcare technology services in developing countries.[1] My Thesis aims to contribute to this process.

1.1.2 Why this Subject is Important

There is general agreement that access to effective health services within a country is an important contributor to development and poverty alleviation. Such services are not available to the majority of the population in many developing countries. One reason for this is a lack of functioning healthcare technology. At the start of my research, for example, the *WHO* reported that in some developing countries the proportion of non-functioning equipment used by the health service may be as high as 80%.[2] This severely affects the health service that can be delivered. Chapter 2 describes the implications of the poor state of the healthcare technology sector in SSA over the last decade and a half.

Health service provision depends upon an extensive range of different types of technology. Although most high technology items are concentrated within large hospitals, technologies of all kinds are a key requirement in all facilities – hospitals, clinics, and health posts – and as part of delivery of primary healthcare through outreach programmes. In fact, the technology present in so many primary healthcare facilities forms a large proportion of the national stock even though it is usually less technically complex.

Within health facilities, the wide range of equipment found is commonly covered by the umbrella term of 'healthcare technology' (usually excluding buildings and grounds). For simplicity, throughout this Thesis the word 'equipment' is frequently used to imply healthcare technology. The wide-ranging variety of equipment falls into a number of categories, as shown in Table 1.1.

TABLE 1.1: Categories of various types of equipment			
I	medical equipment for clinical use	VIII	office furniture
II	fixtures built into the building	IX	office equipment
III	disability aids	X	hardware supplies
IV	hospital furniture	XI	fire fighting equipment
V	service supplies	XII	training equipment
VI	plant	XIII	vehicles
VII	workshop equipment	XIV	communication equipment

Historically, different ministries (such as Works, Health, Supplies, etc) have been responsible for different types of technologies. The range of technology which falls under the responsibility of the Ministry of Health (MOH) varies from country to country; and each MOH's definition of healthcare technology varies depending on the range of equipment types it manages. Many of the types of technologies listed are commonly found in the public and private sectors (boilers, air-conditioners, gas supplies, furniture, tools, etc). However, Category I, for example, includes technology which is specific to health services, requires complex technical skills, and is the responsibility of health service providers alone. These health service providers can be ministries of health, defence, and local government in the public sector, and may include mission, mine, industrial, and commercial facilities in the private/independent sector.

In my research I focus mainly on Category I, but since medical equipment cannot function without Categories IV-VII their status is also considered.

Chapter 2 reports that the health sectors of the countries of Sub-Saharan Africa have little to spend on healthcare technology.[3,4,5] This low level of expenditure in SSA has made it particularly important that the available resources be well used. However, problems have been identified at every stage of use of imported healthcare technology (selection, procurement, installation, day to day use, maintenance, etc). Strategies are required to strengthen the capacity to manage healthcare technology in the region, otherwise any additional funds which are allocated for the purpose are likely to yield little benefit.

Many factors contribute to healthcare technology problems faced by health service providers in developing countries. Much of the existing stock of equipment is very old and is performing poorly, however most countries have not planned or budgeted for its replacement. Most healthcare technology products are designed by industrialized developed countries for their needs; developing countries and external support agencies often make poor choices through lack of technical management skills, and the limited range of suitable products available, as well as inappropriate choices for prevailing climates and conditions. Many external support agencies are involved in funding such equipment and can have a negative influence on the pattern of procurement. Often countries have poor indigenous maintenance resources for broken equipment, weak industrial capacity, and limited support from manufacturers based in industrialized developed nations. The wide range of factors contributing to the poor state of healthcare technology are detailed in Chapter 2.

The ability for equipment to be utilized throughout its life is influenced by its management. For example: choosing suitable products; contractual arrangements with manufacturers; provision of user-training; adequate recurrent budgets for consumables; availability of skilled and resourced maintenance personnel; and so on. In many countries these factors are viewed as unconnected, and piecemeal attempts to correct only one factor fail to improve the situation. Many people have a role to play in the life of technology within the health sector, but many players in other fields and ministries also unknowingly make key decisions which affect the life of equipment. The lack of management and coordination of these various activities and people is a key cause of the problems that have arisen (see Chapter 6).

It is only possible to make effective use of healthcare technology, if there is planning for the overall process. Not only might a health service provider have to cope with the successful importation of such technology into their country, they also have to import it effectively into the local health environment. To achieve this adequately, healthcare technology services must cover a wide range of activities (procurement, safe use, repair, staff training, etc). Thus the successful introduction of a complex technology into the health environment can be viewed as a 'package' of activities, only one of which is the actual purchase of hardware (Chapter 4). When equipment is acquired, provision must be made for all the necessary components of the package. An holistic approach which considers these varied issues has rarely been taken in developing countries. The ability to plan such a range of issues will be dependent on the management skills of the organizations involved and the level of development of the country – both of which often present intractable problems.

1.2 TECHNICAL EXPERIENCE AND APPROACH TO THE SUBJECT

1.2.1 Gaining Background Experience

My technical foundation for this field arose through an initial degree in Electrical Engineering, work in the design of electrical installations for buildings, and research and design in physiological measurements. A subsequent Masters degree in Medical Electronics and Physics provided a fuller understanding of the application, use, and technical requirements of the healthcare technology field through subjects such as: physiology, clinical measurement, electronics and systems analysis of equipment, radiation physics, signal processing of patient data, etc. At that time, graduates could either work for equipment manufacturers undertaking research and development (R&D), sales, or maintenance support; for public sector research institutions; or for health service technical support departments. As might be expected all the training was oriented towards the use and application of technologies designed for industrialized developed nations. Unfortunately, the training contained no elements concerning the management of technology.

My first exposure to the problems for developing countries came from five years employment in the Zimbabwean health sector. Whilst with the Ministry of Health, I planned needs and implemented projects for electro-medical products in health facilities, and when working for the Ministry of Construction I designed and oversaw contracts for the equipment and electrical installations of health facilities nationwide. I discovered a very different reality for the equipment users in Zimbabwe. They faced many technical problems due to inappropriate equipment designed for industrialized developed nations, unsuited to the local climate and conditions. They also faced many management and development problems. For example, supply routes for necessary consumables and spare parts were not available, making it impossible to keep equipment functioning. Manufacturers provided disappointingly limited after sales support, with few local representatives and a poor response. Equipment procurement was constrained by bureaucratic problems and delays obtaining: foreign currency allocations, import licences, customs clearance, payment, etc. Tender rules were hindering the rationalization of the sector. There were immense financial constraints, a shortage of technical personnel, and limited management skills for these activities. Many external support agencies were also involved, but took their own uncoordinated initiatives.

On my return to the UK, I began research into this problem through a one year project at the Institute of Development Studies, where I provided the technical input and Dr G. Bloom provided the health economics input. The idea of considering the 'package' of inputs required to manage the sector and successfully transfer technology was developed. The research led to the publication of a book in 1988, which highlighted the problems of importing technology into SSA, the role of equipment exporters, and the use of a Healthcare Technology Package system framework for analyzing and managing the sector.[3] This forms the starting point of my Thesis.

My concern is how the sustainability of the healthcare technology sector can be improved in developing countries. I have pursued this issue and furthered my experience by:-

* Helping to set up a course for medical equipment maintenance and management aimed at technicians from developing countries, based at the Medical College of St.Bartholomew's Hospital, London.
* Teaching modules on the management of equipment for 14 years.
* Working with WHO on various healthcare technology initiatives.

* Researching successful management strategies for healthcare technology.
* Producing assorted publications and conference presentations.
* Working with donor organizations who struggle to run projects involving healthcare technology.
* Undertaking healthcare technology management consultancies for 13 years.
* Undertaking my PhD research, which provided insights for all aspects of my work.

1.2.2 <u>The Approach Taken</u>

During my early research work I developed a modelling framework – the Healthcare Technology Package system – for looking holistically at all components, 'players', and background conditions required for successful importation of technology into a national healthcare environment (Chapter 4). I have applied this modelling framework to all my subsequent consultancy and research work in developing countries, in order to understand the complete situation when considering the healthcare technology sector.

This Thesis describes the use of this 'tool', studies its effectiveness, and demonstrates the learning process which enabled the tool to be refined. The use of such an approach has generated much empirical data. From the research and this experience it has been possible to identify five key overarching themes (see Section 1.3.2) which dominate the sustainability of the healthcare technology sector, and can be summarized briefly as:

a. the delivery structure for healthcare technology management;
b. technical management capacity;
c. financial resources;
d. private sector support;
e. role of external support agencies.

This Thesis explores these five themes and documents the usefulness of supporting literature in illuminating the problems (see Section 1.4). By undertaking the PhD research, I obtained insights that led me to approach the subject from the three perspectives which create my Thesis framework, and ensure I consider healthcare technology as:

- a technological system
- an institutional organization issue, and
- a development issue.

Figure 1.2 provides a diagrammatic representation of the relationship between my research questions, perspectives, and the key overarching themes. The Thesis explores the importance of understanding these perspectives and the relationship between them in order to improve management of healthcare technology. This approach led to answers to my research questions (Section 1.3.2).

FIGURE 1.2: **Relationship between research questions, perspectives, and key themes**

Q1: How can the sustainability of the healthcare technology sector be improved in SSA?

↓

First Perspective: consider healthcare technology *as a Technological System*

↓

leads to:- An Holistic HTP Framework with 11 components, 4 players & 4 areas of background context → *use of this 'tool' in 3 country trials at 3 different times over a decade*

↓ ↓ ↑

Q2: What are the key constraints to sustainability and what common problems persist?

effectively gather useful data ↓ / ↑ *adapt and refine the application of the tool*

O V E R A R C H I N G T H E M E S:-

a. the institutional framework for healthcare technology management

b. personnel development for a national technical management capacity

c. allocation of sufficient financial resources

d. the technical support available from the private sector

e. the role of external support agencies

Left column (from a.):

↓

Second Perspective: consider healthcare technology *as an Institutional Organization Issue*

↓

Q3: What are the institutional organization constraints to building sustainability for healthcare technology?

↓

explore:-
- managing complexity
- policies and procedures
- shortage of management skills
- poor institutional memory

Right column (from d.):

↓

Third Perspective: consider healthcare technology *as a Development Issue*

↓

Q4: Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?

↓

explore:-
- expansion of numbers of technical staff
- financial strategies
- role of weak national industrial sectors
- influence of external support agencies

I have achieved this end-result in a particular way. Firstly, by looking at the healthcare technology sector in three countries – Zambia, Botswana, Namibia – which are different to each other in a number of features (terrain, economy, population, etc – see Section 5.1). Secondly, by studying the equipment sector at three separate times – Zambia in 1990, Botswana in 1992, and Namibia in 1997 – and observing the changes as I continued to work in these countries in the last decade (Section 3.3.4). In addition, I have attempted to learn along the way, and have changed the country study method in light of the experience in a previous country (Section 3.2). I also believe that the learning process is on-going, and the experience from these three countries will offer assistance to the development of ways to improve sustainability for other countries in future.

1.3 RESEARCH STRATEGIES

1.3.1 Theoretical Approach Taken

As explained, my Thesis framework approaches healthcare technology from three perspectives. I argue that if management of healthcare technology is to be improved, all three perspectives have to be taken into account. From my experience and research, healthcare technology has to function as part of the bigger picture, and be studied from the following viewpoints:-

i) *As a Technological System*. It is necessary to look at the problem holistically and consider healthcare technology as a system, thereby taking into account all the sub-systems affecting the whole. I propose that 11 components are required to import technology into the healthcare environment: i) management and planning, ii) allocation of financial resources, iii) selection of technology, iv) procurement, v) preparation for technology use, vi) continued operation, vii) maintenance and repair, viii) personnel, ix) training, x) technology assessment, research and development, and xi) local production. I also define four categories of 'players' who deliver these different components – health service providers, public sector maintenance organizations, private sector institutions, and the national support environment. In addition there are four areas of study which provide the background context on the national economic and industrial status, and the health and education systems. To successfully transfer technology, all these sub-systems must be considered, the technological issues must be seen as a whole, and the 11 components and four categories of players coordinated and managed within the background context of any country.

ii) *As an Institutional Organization[c] Issue*. The ability to handle a complex network of activities and issues is a management one. Although the managerial ability of individuals is important (eg. whether the procurer has sufficient skills), of equal consequence is the capability of institutions and bodies to undertake processes (eg. whether the range of activities involved in procurement are understood and followed within institutions). Thus it is necessary to integrate humans and technology, together with organizational procedures within institutions, to ensure the continuity of institutional memory of technological issues.

iii) *As a Development Issue*. The issues surrounding healthcare technology vary considerably in different parts of the world; healthcare technology in SSA faces a very different situation to that in industrialized developed countries. Management of this resource has to be effective in very unpromising conditions: deprived of sufficient funds, short of skilled personnel, with only fragmented management capabilities, state led, subject to complex donor interventions, spread over large geographical areas, with poor representation from manufacturers, etc. Thus, any strategies must take into account these specific problems, and review the role of external support agencies[d] and the influence of their development approach.

An understanding of these three perspectives is important, but so is an understanding of the relationship between them. The three perspectives overlap, and considering all at the same time (the overlap) is important if there is to be any hope of success. The idea that a planned technological system is needed seems to contradict directly with the state of flux commonly found in developing countries. Thus the issue becomes how to manage institutional organization issues (point ii), within an incomplete system (point iii), in order to try to get closer to an ideal situation (point i). It will be necessary therefore, to look for creative solutions to an otherwise intractable problem in developing countries.

1.3.2 Research Questions

My main concern is how the healthcare technology sector in developing countries can be managed to improve its sustainability. This Thesis explores the contributing factors and overriding constraints which must be understood, and the initiatives and strategies which will make a difference. The key question is:-

Q1 How can the sustainability of the healthcare technology sector be improved in SSA?

c. In this Thesis, this implies the organization of institutions, and organizational ability within institutions.

d. These are technical agencies of foreign governments, international donors, non-governmental organizations, and financial institutions.

I address this overarching question exactly by approaching the three perspectives identified. I first take a ***Technological Systems*** approach. Healthcare technology is only one example of an imported technology. The problems which have been experienced in the use of imported healthcare technology are common to much of the industrial sector in SSA. For example, reviews of the experience of the capital goods sector found lack of standardization, inadequate maintenance, shortages of inputs, and a scarcity of skilled workers to be major factors in the ineffective use of any imported technologies.[6,7]

It has long been recognized that transfer of technology involves a package of inputs, only one of which is the actual piece of equipment. Thus in Chapter 4, I study the technology transfer literature to see what it can teach and whether it can provide models for success. Much of the literature proved to be disappointing as its emphasis is on the production of commodities, and it measures success in terms of how many products are sold. Ironically little is said about the management required for the hardware itself (the production line). In other words the success of transferring the production process was measured, and not the success of transferring the machinery. As an engineer I was left yearning to know what had happened to the equipment itself, not the final products which were manufactured.

Notwithstanding the limitation of the literature with respect to hardware, a considerable amount of work has been done on 'unpackaging' the transfer of 'productive processes' to developing countries. I believe that a similar approach can be taken for healthcare technology, which is used in the 'production' of healthcare. I present a package of 11 components required to manage the import of technology effectively, four categories of 'players' (public and private) to deliver these different components, and four areas which provide the background context for any country (Section 1.3.1). This modelling framework is used to assess the healthcare technology sector in three country case studies.

It was found that many factors influence this sector. The emphasis for policy-makers has been shifting from further expansion of health services, to making better use of the existing capital base.[8] For healthcare technology, this raises questions about existing policies and procedures of government departments, standardization, financial allocations, maintenance capabilities, regional cooperation, different relationships with foreign corporations, and new models of donor support. The transfer of technology against this background has not been managed well, and substantial problems exist. From my study of the HTP sub-systems, I perceived fundamental recurring themes which are constraining the sustainability of the healthcare technology sector. Thus, a new question is required:-

Q2 What are the key constraints to sustainability and what common problems persist?

The research in three country case studies investigates the problems by unpackaging the technological system, and studying the different activities within each component sub-system of the model. This helps to identify the constraints in the healthcare technology sector for each country (Chapter 5). There are problems with the activities in each of the 11 components, and much has been written about these issues (eg. poor maintenance, inappropriate selection, lack of support for technology). However, as a result of the analysis, five fundamental overarching themes are identified which negatively influence the sustainability of the healthcare technology sector. These are:-

a. The institutional framework available for delivering healthcare technology management throughout the country (Chapter 6).
b. The strategies taken to train personnel and develop a national technical management capacity (Chapter 7).
c. Sufficient allocation of financial resources (Chapter 8).
d. The technical support available from the private sector (Chapter 9).
e. The role played by external support agencies (Chapter 10).

These are large themes that relate to institutional organization and development issues within a country. In order to appraise them, it was necessary to consider my other two perspectives. Thus a study of the technological system leads to the need to take an ***Institutional Organization*** approach. Handling the complex network of activities and issues found will require effective management. Of great consequence is the capability of institutions and bodies in developing countries to organize this process. Thus we must ask:-

Q3 What are the institutional organization constraints to building sustainability for healthcare technology?

In the three country case studies, I investigate mainly the general management capabilities of public sector institutions when dealing with healthcare technology (Chapter 6). As the concept of managing the healthcare technology sector is relatively new for ministries of health, many governments do not as yet have management skills and tools (ie. policies, procedures, regulations) for this sector, or they are only just developing them. The research undertaken found a number of major constraints:-

* A complex network of administrative units within and outside the MOH are involved in the management of healthcare technology, and in the worst cases the colonial legacy has left many different uncoordinated ministries with responsibilities towards health service infrastructure.

* Most developing countries have low numbers of managers (eg. hospital administrators, departmental managers, district directors), and it proves difficult to import healthcare technology management activities into a workplace where there is a general shortage of management skills.
* A high turnover of staff, both in the public sector ministries responsible for healthcare technology as well as in the external support agencies who support this field, makes it almost impossible to retain institutional memories for correctly handling technological issues.

For comparison, I also look at the approach taken by the private and independent health sectors within the three countries. Difficult conditions prevailed in the countries studied, and the public sectors were struggling to achieve effective and continuous utilization of their healthcare technology. In the same conditions and at the same time, the mines, missions, and private sector were running hospitals often with equipment of a similar age and type, but with a larger proportion in good working condition. I study the organizational strategies and philosophies taken in these sectors to see how improved management of healthcare technology is obtained.

In the three countries, I also study the lessons arising from initiatives taken by other industrial sectors when managing their high technology equipment (eg. computers, distilling plant). Their ability to manage maintenance is one very important element of managing technology. Whilst the public sector organizations were struggling to maintain healthcare technology due to common problems (eg. lack of funds, management and technical skills, resources, recognition), Chapters 7 and 9 show that the private sectors were coping better.

The research highlights the constraints within the public sector due to the complexity of institutional organization at hospital level, between different ministries, and within the economy as a whole. Some organizations work better than others, such as the industrial sector, and the strength of this sector is one reflection of how developed a country is. Many institutional organization capabilities are linked to development issues. Thus, a study of institutional organization leads me to consider my third perspective, and the need to take a ***Development*** approach. Thus we ask:-

Q4 Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?

Healthcare technology in SSA is facing a very different situation to that in industrialized developed nations. Developing countries are faced with a low level of resources, limited capabilities, weak economies, and are dependent on the input of external support agencies. Countries face very different realities depending on their national characteristics, so this research is undertaken in three countries with different characteristics. In addition, the research was undertaken at separate times which reflects the changing realities in the past decade. The research highlights situations that illustrate major development issues.

The Thesis recognizes the reality of being a developing country, and thus focuses on two issues which I argue are pertinent to the healthcare technology sector, namely resource and capability constraints. Chapter 7 shows that the shortage of suitable skilled staff in the three countries and the region is a major stumbling block to improving the sector. In addition, Chapter 8 illustrates that the severe financial constraints within the countries, and the poor allocation and management of finances for this sector will affect sustainability well into the future. Additional reflections of the state of development within a country can be seen in two further areas – i) the strength of the private sector to offer technical support, and ii) dependency on external support agencies.

In developed countries, the production and use of healthcare technology constitutes a small part of a complex industrial sector. Health facilities have the full resources of manufacturers and maintainers right on their doorstep. This fact, together with the far greater financial resources available compared with developing countries, means that healthcare technology has continued to function. The well-being of the healthcare technology sector is influenced by factors such as: manufacturers' representation, local industrial capabilities, strong industrial neighbours, policies on trade, etc. In any country, these factors will depend on the economy, industry, technical capability, and regional resources – in other words the private sector support capacity. Thus in developing countries the condition of this technical support environment will be crucial for the well-being of healthcare technology.

For the three case study countries, the technical support environment is reviewed in Chapter 9. The situation in industrialized developed countries, where there is a dense network of organizations with technical expertise, cannot be replicated in developing ones. Developing countries have weak industrial sectors, and international manufacturers have not as yet been obliged to provide more than poor support networks to these customers.

In the 1970s and 1980s, external support agencies were involved in many projects which aimed at expanding the health service infrastructure, such as constructing and equipping a single hospital or a number of smaller health facilities.[9] More recently, rehabilitation projects aimed at re-equipping existing facilities have been funded. The literature shows that evaluation of these programmes found that many facilities were not able to provide the intended services within a few years. The reasons for failure highlight that support generally concentrated on the purchase of equipment and omitted the rest of the healthcare technology package.

In Chapter 10, I study the policies of external support agencies with regard to the supply of healthcare technology, and consider whether they are supporting the management of a sustainable healthcare technology sector. It was found that a minority of external support agencies have actively changed their attitude to provision of equipment in the last half-decade, and now try to support the whole package of inputs. In a situation of scarce administrative resources within developing countries, it is unrealistic to assume that donor policies do not influence the pattern of development.

1.4 METHODOLOGY

In order to consider these research questions, I pursue a number of methodological practices (see Chapter 3):-

i) Systemic, ie. analysis of a whole system and the sub-sets of the system.
ii) Case studies, ie. study of the healthcare technology sector in a variety of countries.
iii) Modelling, ie. using a heuristic framework as a tool.
iv) Multi-method data gathering fieldwork.
v) Focusing on certain aspects of the data generated by the application of the tool – experience has shown that common recurring themes cause the greatest constraints.
vi) Literature review, ie. use of a range of literature throughout the Chapters of my Thesis.

It would not have been possible to review such a diverse range of literature in full. Instead I make judicious use of it to underpin my theoretical approach and illuminate the arguments. The literature in question relates to my three theoretical perspectives as follows:-

* For the technological system – technology transfer and technology assessment literature, and literature on the healthcare technology sector.
* For the institutional organization issues – literature on organizational learning, technical training, human resource development, and technology management.
* For the development issues – literature on the policies and practices of external support agencies, health financing in developing countries, and literature on trade influences and technological development.

1.5. RATIONALE FOR THE THESIS LAYOUT

I approach the layout for the Thesis in the following way:-

The introduction to my Thesis is in the present chapter, and sets up the remaining Chapters. It discusses the aim of the Thesis, my technical experience and approach to the subject, the research strategies, and the rationale for the Thesis layout.

Chapter 2 provides an explanation of why this subject is important, together with a description of the multitude of issues and problems facing the healthcare technology sector in developing countries over the last decade and a half.

The methodology for my PhD research is described in Chapter 3. I develop a holistic approach and a modelling framework for studying the sector. Thus, one aspect of the methodology is this systems approach to the understanding and management of healthcare technology, and the use of a heuristic tool. This modelling framework was tried and reviewed in a number of countries. Chapter 3 describes how this was achieved through data-gathering fieldwork in three different countries (Zambia, Botswana, Namibia) at three separate times (1990, 1992, 1997 respectively). It also describes how experiential development allowed the approach to change from one country to the next.

The healthcare technology sector and the factors influencing it are complex. Chapter 4 argues for the need for the holistic approach taken in studying the healthcare technology sector. A description is provided of the technological system and sub-systems involved. The holistic modelling framework that I have developed through experience is presented as the starting point of my research for this Thesis. The 19 sub-systems are explained in full, indicating the sorts of activities and issues involved. In addition, technology transfer and assessment literature is reviewed here to illustrate the principle of 'unpackaging' the transfer of technology.

The analysis, undertaken by using the modelling framework in each country, generated a great deal of empirical data highlighting constraints within all the sub-systems. Chapter 5 introduces the healthcare technology sector in the three countries at three different times, and compares them by highlighting differing and common features. It provides background by describing the state of the equipment found, and shows that its poor state severely affects the delivery of health services. The research shows that five overarching themes are of greatest significance. These form the subject of the remaining chapters of the Thesis.

Chapter 6 discusses the institutional organization issues in the public, non-governmental, and private health sectors of the countries studied, as well as in the important players from the national support environment. It provides background on the institutional frameworks and organizational skills behind the healthcare technology sector in each case study country. Literature concerning organizational learning, institutional memory, and technology management is used to provide insight into these issues.

There is generally a shortage of suitably skilled technical (and other) staff to manage the healthcare technology sector, within the public sector and country as a whole. Chapter 7 looks at the situation regarding personnel and training in the three countries and the region, as well as presenting possible initiatives. Lessons are drawn from the literature on technical training and human resource development.

Another major constraint is insufficient allocation of financial resources. Chapter 8 compares the financial allocations and constraints in each country and looks to literature for current financing trends for health in developing countries.

The capacity for the private sector to offer support is important for success with healthcare technology. In Chapter 9, the support available is reviewed by looking at the influence of the national industrial sectors, the manufacturers' support networks, the role of neighbouring South Africa, and the implications of trading with industrialized developed nations. Literature on trade influences and technological development is reviewed to see if it can shed any light on this persistent problem. As healthcare technology is only one of many imported technologies into countries, it is important to see if other sectors are coping better. Examples are explored of success with other sophisticated technologies in the country case studies, in order to identify the reasons behind their success. Examples of major development issues are identified.

External support agencies can have a profound effect on healthcare technology in developing countries (for good and bad). Chapter 10 discusses their influence and the resultant problems, current trends, and future needs. Literature on donor policies and practices is reviewed. Further examples of major development issues are identified.

My Thesis concludes (Chapter 11) with a summary of the findings and a resolution of the research questions. It shows how the research provided me with insights into the healthcare technology sector, and led me to view the sector from three perspectives at the same time. It also presents my claims to originality.

CHAPTER TWO: THE POOR STATE OF THE HEALTHCARE TECHNOLOGY SECTOR IN SSA

This Chapter sets the scene for the Thesis and looks at why the subject of Healthcare Technology is important. It details the multitude of issues and problems facing the healthcare technology sector in developing countries, which first attracted my attention. The data presented describes the starting point of the Thesis in the late 1980s, and the changes that have occurred during the Thesis research period in the last decade. It argues that key issues must be addressed to improve the sustainability of healthcare technology in Sub-Saharan Africa, thus providing the background to my key research question:-

Q1 How can the sustainability of the healthcare technology sector be improved in SSA?

2.1 THE CRISIS IN THE HEALTH SECTOR

The health sector is in a state of crisis in most countries of Sub-Saharan Africa. A number of countries have experienced growth in numbers of both health facilities and trained health workers. Nonetheless, large proportions of the population still do not have access to effective health services.

An important contributor to the crisis has been severe financial constraints facing health services in the region.[10,11] At the start of my Thesis, a study by the *United Nations Children's Emergency Fund (UNICEF)* reported that of the 15 countries for which data on per capita health expenditure were available in SSA, 7 showed a decline during the period 1979–1983.[12] For a number of countries in SSA the fall had been dramatic, with average annual fall in health expenditure per capita ranging from 6.6 per cent (Mauritius) to 15.8% (Ghana).[13] The case of Zambia illustrated just how serious the situation could be; *Freund* estimated that real per capita expenditure on health in 1985 was only 37 per cent of that in 1970.[14] By 1994, the *World Bank* reported that although the average health expenditure per capita in the "high" expenditure group of countries (representing one-twentieth of Africa's population) was 68 United States dollars (US$) (ie. Zimbabwe, Botswana), for the "medium" group (30% of SSA's population) it was only US$ 16 (ie. Zambia, Ghana), and in the "low" group (two-thirds of SSA's population) only US$ 8 (ie. Burkina Faso, Ethiopia).[15]

Lack of resources means that existing services have been seriously compromised. The *WHO Regional Office for Africa* in 1985 reported that a number of countries identified this as a serious problem.[16] In the case of Zambia, for example, an *International Labour Organization (ILO)* mission found that the health services in one province lacked virtually all resources except personnel.[17,18] In 1997, the *WHO's* index for overall health system attainment for 191 countries saw all the countries of SSA placed in the bottom 54 rankings.[19]

When funding to the health sector fell, not all inputs decreased. The *UNICEF* study reported that the greatest cuts were in capital expenditure, followed by purchase of consumable goods. The least vulnerable to cuts were wages and salaries. In fact, in a number of cases where total health expenditure fell between 1979 and 1983, there was a rise in payments to employees.[12] The *European Economic Community (EEC)* reported in 1986 that wages and salaries frequently accounted for over 60 per cent of recurrent expenditure and in some countries had reached 85 per cent.[20] This situation was still being reported by *WHO* in 2000.[21] The consequence is that trained personnel based in health facilities (often newly constructed) cannot be effective due to a lack of drugs and consumable inputs, deteriorating buildings, and non-existent transportation. The investment in effort and financial resources made over the last decade is, in these circumstances, of relatively little benefit.

Access to effective health services is an important contributor to development and reduction in poverty (*Halstead et al*).[22] But such services are not available to the majority population in many countries.

2.2 THE PROBLEM OF HEALTHCARE TECHNOLOGY

One well-documented element in this crisis is a lack of functioning 'healthcare technology' – a term covering many categories of equipment (see definition in section 2.3.1). Summaries of evaluations carried out by, among others, the *United Nations Development Programme (UNDP), WHO,* and *EEC* all reported that health facilities frequently have very little functioning equipment.[2,14,20,23-25] This is because the facility was inadequately equipped to start with, or provision has not been made for replacing equipment as it wears out. A large proportion of the available equipment is not working. In addition, large quantities of equipment cannot be used due to shortages of inputs, such as x-ray film and chemical reagents, necessary for the provision of an on-going service. For example, *Issakov* of WHO reported in 1990 that in most developing countries the proportion of both clinical equipment and engineering plant which is not functional is seldom less than 50% and in some countries was as high as 80%.[26]

The consequences of lack of money are compounded by inefficient use of available resources. The equipment purchased is frequently inappropriate to the local environment. Inadequate consideration is given to the inputs required for the equipment to provide an effective service. Operators are often untrained, and little provision is made for maintenance. The useful life of equipment is, therefore, significantly shortened. Expensive units are unusable due to minor faults that, in other circumstances, could be easily corrected. In many countries, equipment has come from a wide variety of suppliers, and this lack of standardization increases difficulties with sustainability.

The lack of functioning healthcare technology is only one aspect of the broader crisis in the health sector. Nonetheless it has a serious impact on the overall effectiveness of the services provided. Furthermore, the purchase of equipment, and the inputs to keep it functioning, represents a significant expenditure of health finances and foreign currency.

2.3 CONTRIBUTING FACTORS

There is a broad spectrum of factors contributing to the lack of functioning equipment in developing countries:-

2.3.1 <u>The Wide Range of Equipment Types</u>

Health service provision is built upon a foundation of an extensive range of different kinds of equipment. For example, health facilities contain boilers to heat water, ovens to cook patients' meals, and operating theatre lights to illuminate surgical activities; in addition they have specialized medical equipment such as chemical analyzers for laboratory tests, x-ray machines to aid diagnosis, and ultrasound for physiotherapy treatment. For simplicity the word 'equipment' is used in this Thesis to imply 'healthcare technology', the umbrella term covering the following categories:-

I medical equipment for clinical use (eg: x-ray units, diathermy machines, suction pumps, scales, foetal dopplers, autoclaves, infant incubators, physiotherapy units, centrifuges)
II fixtures built into the building (eg: scrub-up sinks, fume cupboards, ceiling-mounted operating theatre lights)
III disability aids (eg: wheelchairs, crutches, prostheses, hearing aids, spectacles)
IV hospital furniture (eg: hospital beds, cots, trolleys, infusion stands)
V service supplies (eg: electrical installations, water, sewage, and gas pipelines)
VI plant (eg: boilers, lifts, air-conditioning, refrigeration, incinerators, cookers, washing machines)
VII workshop equipment (eg: hand and bench tools, test equipment)
VIII office furniture (eg: desks, chairs, cupboards, filing cabinets)
IX office equipment (eg: computers, printers, photocopiers)
X hardware supplies (eg: stainless steel ware, plastic ware, glassware)
XI fire fighting equipment (eg: extinguishers, hose and sprinkler systems)

XII training equipment (eg: overhead and slide projectors, video and tape recorders)
XIII vehicles (eg: ambulances, cold-chain motorbikes, mobile workshops)
XIV communication equipment (eg: telephones, two-way radios, nurse-call systems, paging systems).

Historically, different types of technologies have been the responsibility of different ministries (such as Works, Health, Supplies, etc). Thus, the range of equipment which falls under the responsibility of the Ministry of Health varies from country to country; and each MOH's definition of healthcare technology will vary depending on the range of equipment types they actually manage (finance, procure, and maintain).

The technology in Categories V-XIV is common to many institutions both public and private, and to many ministries, and has been around for many years (often more than 50), so countries may have developed ways of dealing with them. Categories II-IV tend to be more specific to the health sector, but are generally of a type of technology which requires basic mechanical, plumbing, carpentry or electric skills to ensure they are maintained, with such skills generally available in the public and private sectors. However, Category I is specific to health facilities, and health service providers alone have to attain technical skills to cope with it. These health service providers may be ministries of health, defence, and local government in the public sector, or mission, mine, industrial, and commercial facilities in the private/independent sector. The focus of my Thesis research is mainly on Category I, but since medical equipment and the clinical services it supports cannot function without Categories IV-VII their status is also considered.

Over the years there has been increased dependence on equipment, and increasing dependence on ever-evolving technology. Since the 1950s the number of electrical items has been increasing, and since the 1970s the number of electronically sophisticated items has been rising steadily with the micro-processor playing an ever-increasing role. Healthcare technology is continually developing in complexity, sophistication, automation and cost. There is a vast amount of technology now in hospitals (see Table 2.1), and the range of goods available on the market for hospital use is rapidly expanding. In 1987, the *Canadian Department of Health and Welfare* reported that 5-10% of medical devices on sale in one year were not available during the previous one, and 100,000 trade names were included in its register of medical devices.[27] By 1994, *Nobel* of the Emergency Care Research Institute (ECRI) reported that 750,000 medical devices were on offer on the world market produced by 10,000 manufacturers. He estimated that this figure would double by 2000.[28]

Therefore health service providers must be able to use and maintain a wide and diversifying range of items; and as the technology becomes more complex, management requirements change and become more pressing. It is no longer possible for health service managers to

TABLE 2.1: Examples of the types of complex equipment in health facilities

Category I		
Radiography	x-ray apparatus x-ray film processors dental x-rays	CT scanners fluoroscopy suites radiotherapy units
Laboratory	centrifuges microscopes incubators haemoglobinometer	blood-gas analyzer hot-air ovens calorimeter spectrophotometer
Operating theatre	operating tables surgical diathermy units surgical lasers	theatre lights suction pumps defibrillator
Anaesthesia	anaesthetics machines/trolleys pulse oximeters	anaesthetic ventilators oxygen analyzers
Monitoring	ECG (electrocardiograph) foetal	EEG (electroencephalograph) EMG (electromyograph)
Intensive care	infusion pumps infant incubators oxygen therapy units	resuscitation carts phototherapy units ICU ventilators
Central Sterile Supply Dept.	sterilizers	autoclaves
Pharmacy	tablet counters	water stills
Clinical	stethoscopes ophthalmic equipment refrigerators	sphygmomanometer dental equipment scales
Physiotherapy	short wave electrical infrared	ultrasound ultra violet
Ultrasound	diagnostic ultrasound	monitors & tape recorders
Dialysis	dialysis machines	water treatment plant
Category V		
Services	water & sewage installations electrical installations	domestic gas installations medical gas installations
Category VI		
Kitchen	fryers food-warmers	ovens cold-stores
Laundry	washing machines tumble dryers	hydro-extractors roller-ironers
Plant, general	mortuaries boilers lifts compressors	electrical generators air-conditioning plant incinerators vacuum pumps

persuade themselves that managing technology is not part of their role, however much they are phobic to the term 'technology' and the task in hand.

2.3.2 Understanding the Quantities Involved

A first step towards understanding the issues involved in planning and implementing a change in the equipment service is to estimate its overall size. At present, in most countries it is not possible to review records of purchase of equipment or equipment inventories in the health sector. The size of the equipment stock to be managed is generally unknown. It has been necessary to study international trade data in order to estimate some trends in the market for equipment in the region.

Imports of equipment to Sub-Saharan Africa

There exists no simple method for estimating total expenditure on healthcare technology in the region. It is difficult to identify funds used for this purpose in published public sector accounts, and there is no information available on equipment purchases by other providers. What can be documented, on the basis of available data, are the total imports of some categories of medical equipment. Since there is no evidence of substantial production of these goods in SSA, the supply of medical equipment to the health sector derives almost entirely from overseas purchases.

The term 'medical equipment' includes a wide range of different kinds of equipment and apparatus. International trade data are limited to those commodities identified in the *United Nations' (UN)* Standard International Trade Classification (SITC).[4,29-31] These data have serious limitations. Some categories may include items whose use is not reserved to the health sector. On the other hand, some medical equipment will not be included in any of the special categories. Table 2.2 shows eight categories which appeared relevant to the health sector in 1985[32,33]; but by 1995 the SITC categories had been revised, the records were not sufficiently detailed to show trade by the sub-categories involved, and African countries were not recording the level of detail required.[34] This highlights the difficulty of identifying all healthcare technology items, and the mixture of equipment and consumable items. It also makes comparisons for total import estimates impossible. However, total imports of such commodities to SSA in 1985 amounted to US$120 million (SSA was classified at that time as 39 countries excluding South Africa and Namibia).

TABLE 2.2:	Imports of medical equipment by Sub-Saharan Africa (SSA) 1985 [US $ million]		
SITC - Rev 2 (Rev 3 change from 1986)	**Description**	**Africa**	**SSA**
628.1[1] (629.1)	Hygienic and pharmaceutical articles of rubber	4.931	NA
774.1	Electro-medical equipment (except x-ray)	27.349	5.591
774.2[2]	X-ray apparatus	58.960	11.869
821.21[1,2] (872.4)	Medical, dental, surgical, or veterinary furniture	27.711	13.907[3]
848.22[1] (848.2)	Articles of apparel and clothing, rubber gloves	3.109	NA
872	Instruments, equipment and appliances	183.102	64.535
882.21 (882.2)	Photographic plates and film	39.239	18.754
899.6	Hearing, orthopaedic aids	26.458	2.675
	Total	**370.859**	**approx 120.000**

1. Exports from OECD countries only (in f.o.b. prices).
2. Exports from Canada not available.
3. Includes imports by Tunisia, Morocco, and Libya.

Sources: United Nations, International Trade Statistics Yearbook, 1985.[32]
OECD, Annual Foreign Trade Statistics by Commodities, microfiche, 1985.[33]

Tables 2.3 and 2.4 show SSA's share of imports of medical equipment over a decade. By 1995 data was less detailed and reliable since the two volumes of the *United Nations' International Trade Statistics Yearbook* appeared to contradict each other.[34]

TABLE 2.3:	Imports of medical equipment to SSA[1] in relation to total world imports for 1985[2]			
Description	**SITC (Rev 2)**	**Imports to SSA [US$ million]**	**Total world imports [US$ million]**	**Imports to SSA as % of total imports**
Electro-medical equipment (except x-ray)	774.1	5.59	1,609.00	0.35
X-ray apparatus	774.2	11.87	1,819.55	0.65
Instruments, equipment and appliances	872	64.54	4,042.08	1.60
Photographic plates and film	882.21	18.75	1,505.62	1.25
Hearing, orthopaedic aids	899.6	2.68	1,118.04	0.24
	Total	**103.43**	**10,094.29**	**1.02**

1. SSA is defined as all of Africa excluding Algeria, Egypt, Libya, Morocco, Tunisia, and the South African Customs Union.
2. Data on SITC 628.1, 821.21, and 848.22 are not reported in the UN International Trade Statistics Yearbook and are not included in this table.

Source: United Nations, International Trade Statistics Yearbook, 1985.[32]

TABLE 2.4: Imports of medical equipment to SSA in relation to total world imports for 1995[1]							
SITC (Rev 3)/Description	Total world imports [US$ million]	Imports to Africa [US$ million]	Imports to Africa as % of total imports	Imports to SSA, Method 1[2] [US$ million]	Imports to SSA as % of total imports	Imports to SSA, Method 2[3] [US$ million]	Imports to SSA as % of total imports
774/ Electro-medical equipment and X-ray apparatus	10,924.6	222.0	2.0	129.4	1.2	43.2	0.4
872/ Instruments, equipment and appliances	18,308.8	487.5	2.7	116.3	0.64	85.2	0.47

1. Data on SITC 629.1, 872.4, 848.2, 882.2, and 899.6 are not reported in the UN International Trade Statistics Yearbook Vols I & II and are not included in this table.
2. Total for Africa as a whole (from Vol II) minus individual listings for South African Customs Union and North African countries (from Vol I), in order to make a comparison with the 1985 definition of SSA.
3. Total of individual listings for SSA countries (from Vol I), as defined in 1985.

Sources: United Nations, International Trade Statistics Yearbook, 1997, Vols I and II.[34]

In the decade from 1985 to 1995, world imports of electro-medical equipment (including x-ray apparatus) rose three-fold, and of instruments, equipment, appliances by 4.5 times. Depending on the calculation used, the imports to SSA of electro-medical equipment may have risen in 1995 by 2.5 – 7.5 times, and of instruments, etc 1.5 times. However, although in 1985 the share of world imports of electro-medical equipment to SSA was 0.51 per cent and of instruments, etc was 1.6%, by 1995 the SSA's share was still only 0.4 – 1.2 % and 0.47 – 0.64% respectively of the world total (depending on the method of calculation used).

Thus the health sectors in the countries of SSA must make do with very small quantities of medical equipment. SSA's percentages are even lower if compared to total world sales of medical equipment (eg. items traded nationally and internationally), estimated to be US$ 30 billion in 1985.[35] *Issakov* reported the total world market for medical equipment and supplies (excluding pharmaceuticals) in 1991 to be US$ 71 billion.[5] It is not possible to estimate current world sales since the trade statistics only record cross-border sales (exports and imports) and not in-country sales.

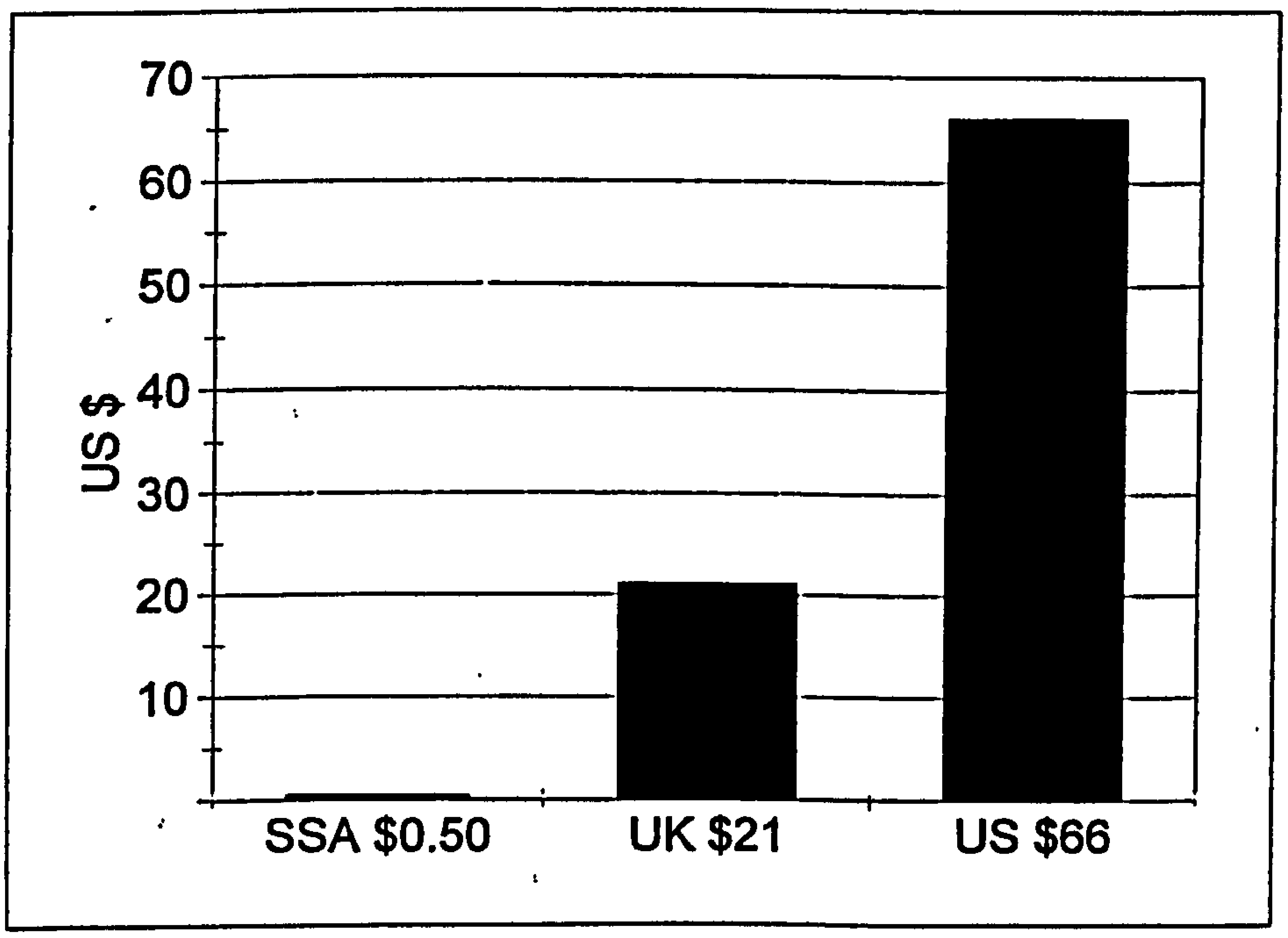
In 1995 the *UN* estimated the total population of SSA (excluding South Africa and the five North African countries) to be 532 million, or 9.4 per cent of the world total.[36] But its share of equipment imports is well below 1 per cent. The overall impression this research gives is the small proportion of total world production of medical equipment which goes to SSA countries.

2.3.3 Lack of Expenditure on Equipment

A shortage of funds

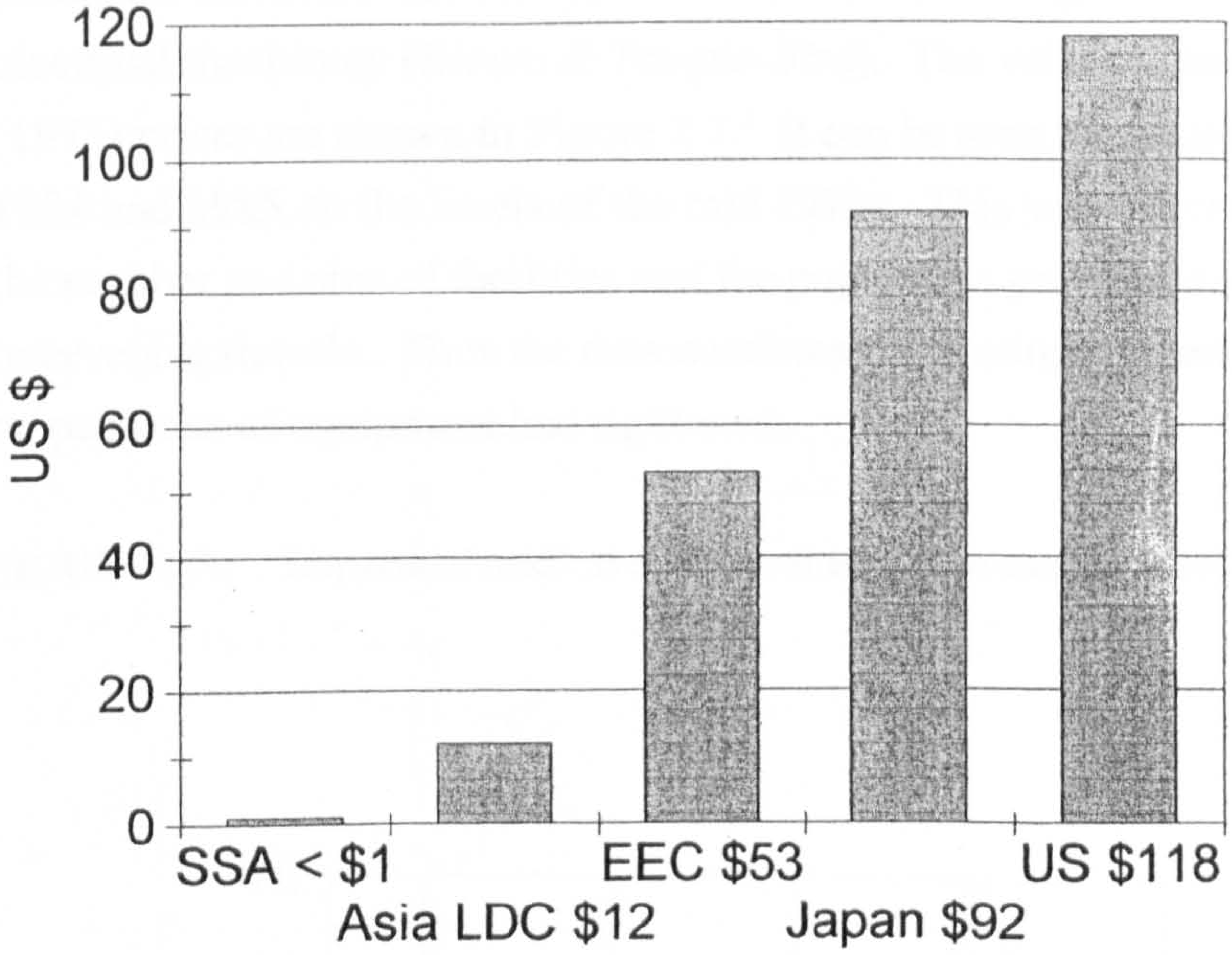
One reason why many countries suffer from severe shortages of functioning healthcare technology is simply lack of money. The health sectors of SSA countries have little to spend on equipment. This is illustrated in Figures 2.5 and 2.6, which compare the levels of expenditure on medical equipment per person in SSA and other countries over a decade. *Bloom & Temple-Bird* found that in 1985 per capita expenditure on these items by SSA was less than one-hundredth of that by the United States (US); SSA spent under US$ 0.50 per person, while Great Britain and the US spent $21 and $66 respectively.[3] In 1991 per capita expenditure by SSA had fallen in relation to other countries; SSA spent under US$ 1 per person, while developing countries in Asia spent US$ 12, European Community countries spent $53, Japan spent $ 92, and the US spent $118 (*Issakov*).[5]

FIGURE 2.5: **Expenditure on medical equipment per capita, 1985**



Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: a framework for policy formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

FIGURE 2.6: Expenditure on medical equipment per capita, 1991



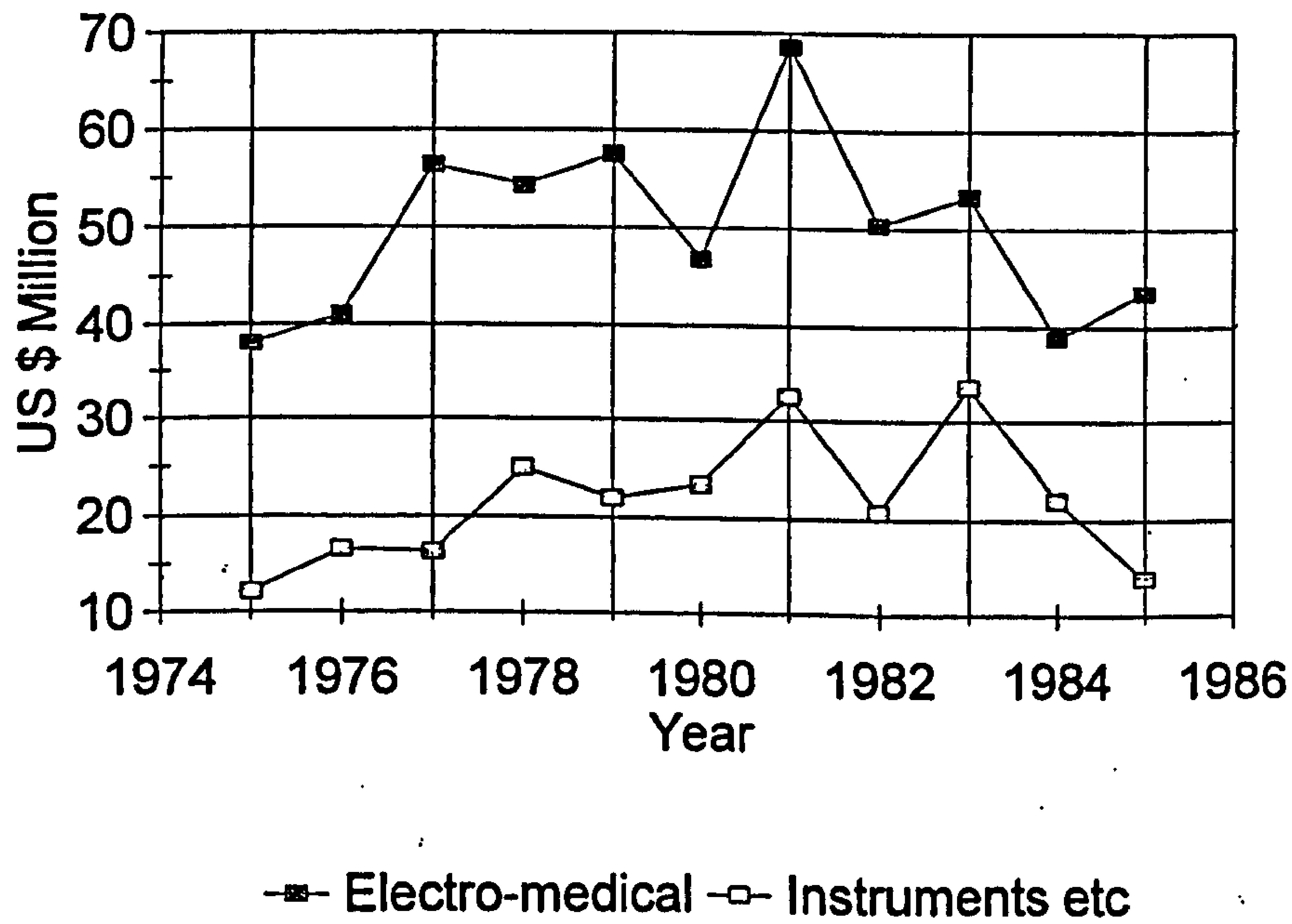
Source: Issakov, A., 1996, Equipment Management and Maintenance in Developing Countries, unpublished paper, WHO, Geneva [5]

The value of imports

During the decade 1975 – 1985 the value of imports of medical equipment to SSA varied considerably.[33] Imports of electro-medical equipment more than trebled; from US$ 12 million in 1975 to $ 43 million in 1981. Similarly, imports of medical instruments, etc rose from $ 38 million to $ 103 million. By 1985, however, imports had fallen back to $ 17 million and $ 65 million respectively. It was not possible to extract the same level of information from the *1997 UN Trade Statistics Yearbook*, however it was possible to see that imports varied considerably across the region over time. Some countries in SSA did not record the import of a SITC category of medical equipment at any time in the period 1993-1997, others might import one year and not the next, whilst others had regular imports.[34]

In order to estimate the 'real' value of imported equipment it is necessary to compensate for inflation. There is no simple method for this especially for commodities such as medical equipment, where technical progress is rapid. If there have been improvements to equipment without a rise in price, the dollar cost of imports will underestimate their value to the health sector. On the other hand, where new models are less reliable, less durable, and more costly to maintain, value for money may fall. Furthermore, prices of those goods imported by SSA might not have followed the general trend. In spite of the difficulties, it is useful to estimate the real value of imports of medical equipment. For the 1985 figures the price of the imports of electro-medical equipment were deflated by an index of world export prices for electrical machinery, and those of other categories deflated by an index for non-electrical machinery (*Bloom & Temple-Bird*). The values obtained of imports in constant (1975) prices are shown in Figure 2.7.[3] It can be seen that expenditure had dropped, in 1984 and 1985, to the levels of the mid 1970s. This was the case in spite of an expansion in the number and size of facilities and the population growth which had occurred in the intervening decade. Thus the data confirms that during the early 1980s, financial constraints on purchase of equipment had tightened.

FIGURE 2.7: Imports of medical equipment to SSA in constant (1975) prices



Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: a framework for policy formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

The prolonged economic crisis poses the threat of serious compromise to the health sector if the decrease in equipment purchase budgets is maintained. Evaluations and reports from the region show that for many countries a lack of functioning medical equipment is a serious problem.[2,8,20]

The use of aggregate data for a region as large and diverse as SSA can be very misleading. Some countries have been facing severe resource constraints for a number of years. For example, Mozambique, Zaire, Ethiopia and Malawi consistently imported small quantities of electro-medical equipment, while Nigeria was able, during the oil boom, to increase its purchases substantially.[3] Internal disparities can also be very important. In a number of countries a large proportion of the total equipment stock is concentrated in a small number of hospitals – usually a few central tertiary ones (*World Bank*).[37] The remaining health service may be deprived in spite of relatively high levels of national expenditure. The case of pre-Independence Zimbabwe provides a stark illustration, when the government construction programme was dominated by a sophisticated new hospital in the capital.[38] Equipment was purchased to establish a new intensive care unit, coronary care unit, burns unit, and renal unit. At the same time, most facilities in the country were severely constrained by equipment shortages. The existence of such disparities between and within nations means that the amount of equipment purchased for use in facilities which provide a basic level of outpatient and inpatient care will only be a fraction of total imports.

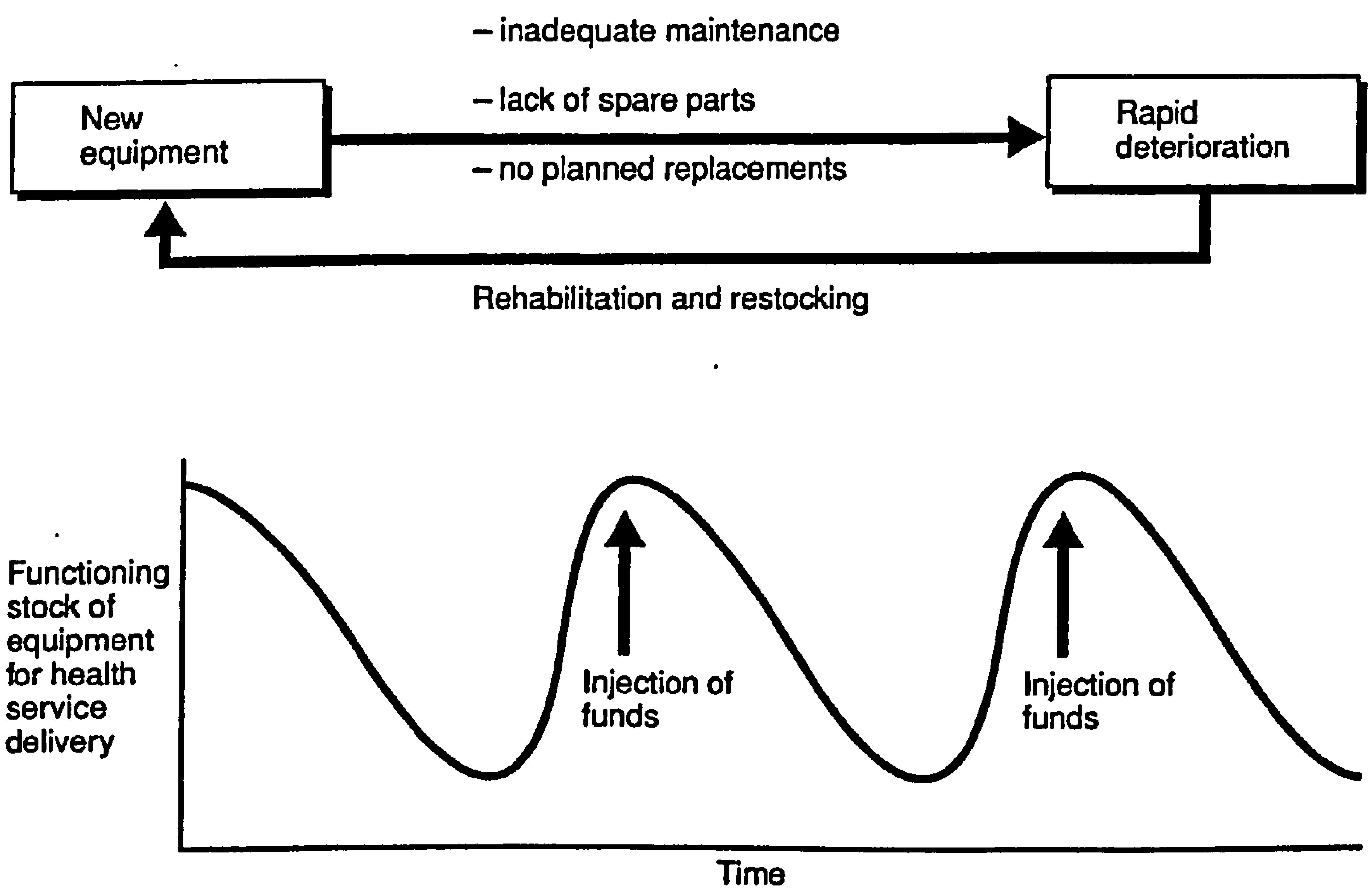
Fluctuations in financial resources

If newly purchased healthcare technology is to continue providing services, substantial funds are required annually to pay for consumable inputs, maintenance, and replacement of stock. The total cost of buying, installing, operating and maintaining a piece of equipment is called its life cycle cost.[39] This may be equal to two or three times the initial purchase price. In many cases such expenditure has not been anticipated and adequate provision has not been made. As a result trained personnel and expensive facilities are rendered ineffective by a lack of functioning equipment.

In a number of countries one can discern the development of a recurring cycle in the equipment sector (Figure 2.8). New equipment is purchased and installed. This is followed by a rapid decrease in its effectiveness. Finally a crisis occurs in the health service and a rehabilitation operation is undertaken. The purchases may be funded locally during a period of relative prosperity, or they may be part of a programme of support by international donors. The seriousness of this problem has been underlined by the *Court of Auditors of the EEC* which has warned that future aid may find itself increasingly being allocated simply for the "rehabilitation" of earlier projects.[40]

The cyclical approach to funding the equipment sector does not give good value for money. A lack of inputs and maintenance leads to a rapid deterioration of equipment so that little benefit derives from the capital investment during much of the cycle. Typically, little effort is made to standardize equipment and small contracts are given to several suppliers, making cost-effective selection of stock difficult. In the absence of an assured budget it is very difficult for the public sector to plan a system of maintenance and regular replacement of equipment. There is also little incentive for suppliers to offer back-up services locally. The result is an expensive but ineffective equipment service whose financing is dependent on cyclical injections of aid funds (see Chapter 8).

FIGURE 2.8: The equipment cycle



Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: a framework for policy formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

2.3.4 Age of Equipment and Replacement Needs

All equipment has a life expectancy, which varies with the type of equipment and type of technology involved in its manufacture. For example, the *American Hospital Association* estimates the life expectancy for an electrocardiograph (ECG) monitor as approximately five years; a suction pump ten years; an operating table 15 years; and a boiler 20 years.[41] All equipment is made up of moving and non-moving parts; these parts can fail due to wear and tear, and a point will be reached when they can no longer be repaired and will be at the end of their natural 'life'. At this time, there is no choice but to replace the equipment if the service it offers is to continue. Although some items stop working at the end of their lives, others can give the impression of working although their operation may be ineffective or unsafe, and maintenance costs uneconomic.

Often equipment is not replaced at the end of its life. Developing countries rarely use depreciation accounting or have replacement budgets. Requests for replacement equipment are often seen as extravagant expansion rather than maintenance of the status quo. The result is shortfalls in equipment because old items are never replaced, old equipment still maintained although no longer economically viable, unreliable, or ineffective. Commonly health facilities in developing countries are full of ancient equipment – even 30 – 40 years old; with no replacement since the facilities were first built (see Chapter 5).

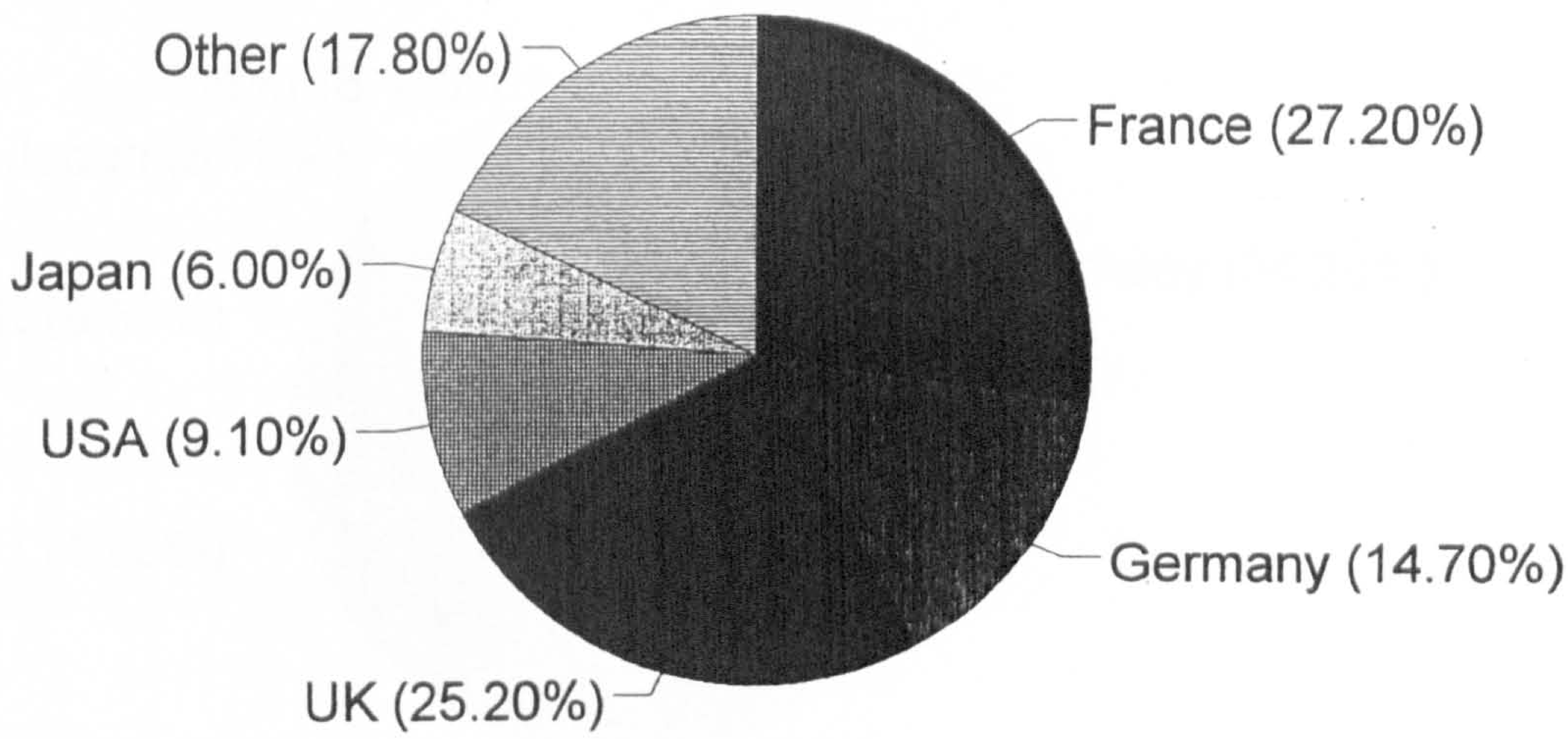
With equipment stock of this age, initiatives for rehabilitation (currently popular with donor agencies) are of limited use. In reality the countries need major stock replacement. As no plans were made for gradual annual replacement of items as they reach the end of their lives, countries need bulk replacement of their stock all in one go – the time for rehabilitation has gone. This requires major capital investment for healthcare technology if the population is to have access to effective health services.

2.3.5 Poor Selection and Limited Choices

Sources of supply of medical equipment

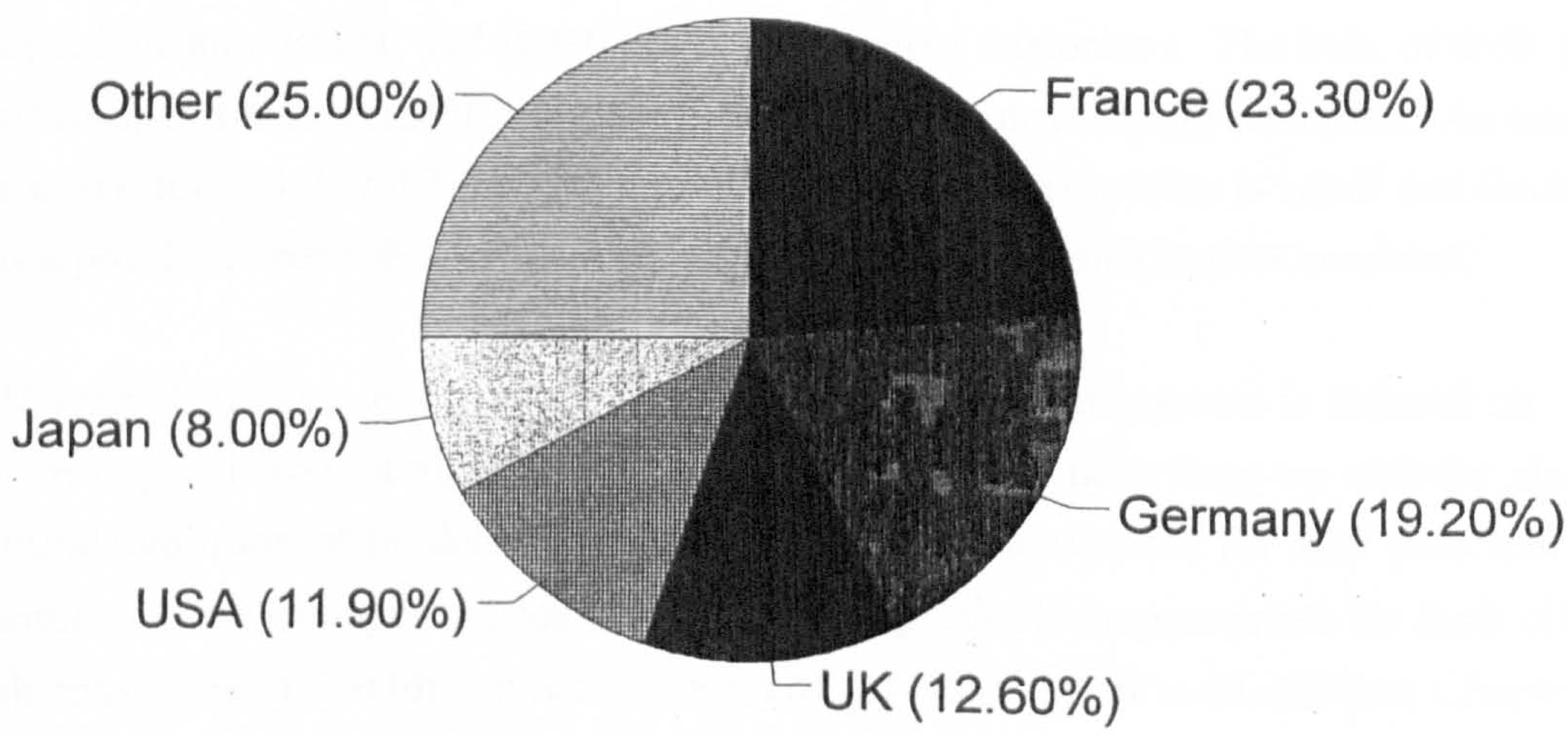
In 1985, world trade in medical equipment was dominated by three countries; the Federal Republic of Germany, the US, and Japan accounted for more than half of total exports of both medical instruments and electro-medical equipment.[32] They still dominated in 1997.[34] The *UN* and the *Organization for Economic Cooperation and Development (OECD)* report that a number of European countries, including the United Kingdom (UK), France, Italy and the Netherlands, have a significant share of the world market.[32-34,42-44] The sources of supply to SSA reflect, to a large extent, the region's colonial past. France, the UK, and Germany were the major suppliers of both electro-medical equipment and medical instruments in 1985 (see Figures 2.9 & 2.10). As Figure 2.11 shows, in 1990 Germany and the UK had regained their position for electro-medical equipment and Italy had overtaken the US and the Netherlands, that mainly exported to the parts of Africa outside the Sub-Saharan region.[44] Other producers, such as South Africa, have increased their presence although still with very small market share (see Chapter 9).

FIGURE 2.9 Major OECD suppliers of medical instruments (SITC 872) to SSA, 1981-85



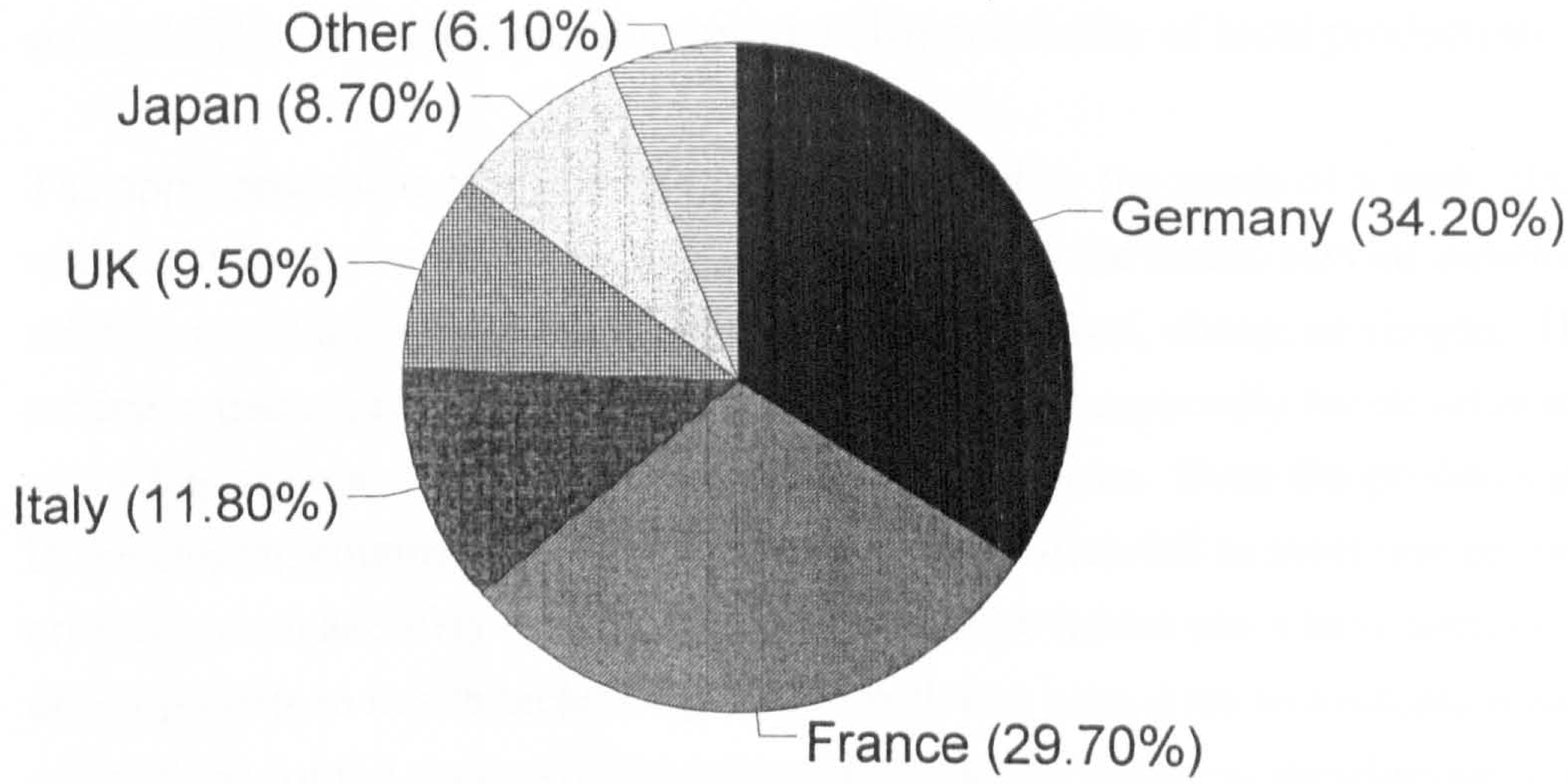
Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: a framework for policy formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

FIGURE 2.10: Major exporters of electro-medical and x-ray equipment (SITC 774) to SSA, 1981-85



Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: a framework for policy formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

FIGURE 2.11: Major exporters of electro-medical and x-ray equipment (SITC 774) to SSA, 1990



Source: United Nations, Bulletin of Statistics on World Trade in Engineering Products, 1990 [44]

Appropriateness of design

Since the major manufacturers are from industrialized developed countries, the hospitals of Europe, North America, and Japan are their principal customers. The bulk of their products are developed for this major home market, and not for developing countries. As can be seen in section 2.3.2 and 2.3.3, the market in developing countries is small and intermittent. Thus a problem arises due to the level of technological sophistication involved.

As *Hartley & Hutton* report, product development for manufacturers is focused on maintaining a share in a highly competitive market. They must keep up with (or ahead of) the rapid evolution of models incorporating the latest innovations for their principal customers. Developing countries often find these products inappropriate for their climate, harsh environment, health service offered, and service support available (see Chapter 9). The generally accepted view is that "basic" equipment, designed for developing countries, cannot be sold more widely and there is not, at present, a secure market for such products. Thus there is no economic incentive to invest significant resources in R&D for appropriate technology.[45]

The *WHO's* Alma Ata report stressed the importance of utilizing appropriate technology for the success of primary healthcare.[46] *Lechat* and *Jordan* put forward a number of criteria to be used in assessing equipment. These include: (1) relevance to health problems, (2) safety, (3) effectiveness, (4) low life-time cost, (5) ease of use, (6) ease of maintenance, (7) capacity to function in the local environment, (8) acceptability by the local community, (9) accessibility to the local community, and (10) possibility of local production.[47,48]

The appropriateness of a technology is determined by the needs of a particular society. This will differ from country to country and over time, as the health service develops. It is a mistake to equate appropriateness with locally produced, cheap, or simple. There is no evidence that appropriate equipment is manufactured especially for developing countries according to how well it meets the criteria set out above. Even the products manufactured in developing countries (such as India and China) often fail to meet one or more of the criteria – such as safety or effectiveness. Although recent years have seen numerous developments in health technology, little work has been done to evaluate possible adaptations for the successful transfer of these technologies to developing countries. Investment in research into new products is the motor which pushes the development of healthcare technology. Virtually no such expenditure is being made in SSA (Section 9.4).

2.3.6 Influence of External Support Agencies

A significant proportion of equipment purchases to the health sector is funded by external support agencies[e]. The policies of these 'donors' influence the pattern of procurement by health service providers (see Chapter 10).

Donations of pieces of equipment

As *Gilchrist* reiterates donations usually circumvent selection and procurement systems.[49] The equipment is almost invariably manufactured in the donor country. Local representatives, which may be requested to provide technical support in the future, are by-passed. Problems of operation, purchase of consumable inputs, and maintenance can mean that very little benefit is derived by the recipient.

Tied aid

Tied aid limits procurement to products from the donor country. The impact can be similar to that of donations in kind. One reason for the great diversity of equipment in many countries has been tied aid by a number of donors. The acquisition of equipment requires a commitment of at least 20 percent of purchase price to sustain the service (an average of 10% for replacement per year, 6% for maintenance, as well as funds for consumable items).[3]

e. See footnote d. (Chapter 1)

This will be much greater if there are difficulties with maintenance, and the purchase of spares. In some cases costs may outweigh the benefit of receiving the equipment.

Competitive international tender

International tenders are the required mode of procurement for several agencies, including the EEC, WHO, and World Bank. In some cases this too has created difficulties. The conflict between the advantages gained from standardization, and the desire to invite competition presents special problems. If the kind of equipment already in place can be taken into account when adjudicating a tender, it could be argued that competitors are unfairly excluded. But most countries of SSA represent such a small market for healthcare technology, that the efficient organisation of maintenance and the supply of spare parts require a considerable amount of standardization. In recognition of these difficulties, the Lomé III Convention (1984) established "economically most advantageous" as the criterion upon which bids should be judged, in the case of aid from the *EEC.*[50] This provided an opportunity for strong procurement units to specify guidelines which ensured the needs of equipment services were considered in the selection of bids. However, many donors have not applied this criteria with any rigour. Pressures to economize mean the cheapest option wins.

2.3.7 Equipment Not Working – Poor Maintenance Resources

Up to the mid–1980s, once equipment was purchased and installed in a health facility, policy makers or administrators paid little attention to how to continue the service. In 1986, the failure of many health services to make good use of the available healthcare technology was the topic of an inter-regional workshop organised by *WHO.*[2] The meeting detailed the common reasons why equipment was out of order (see Table 2.12). Maintenance services, typically, had insufficient skilled staff and tools, poor workshop facilities and financial resources, little access to transport, and a poor understanding of their problems by health administrators.

TABLE 2.12: Reasons why equipment may be out of order

1. Basic equipment in need of simple repairs
2. Poor performance of equipment in use
3. Mis-use of equipment
4. Lack of simple maintenance
5. Unsuitable environment
6. Inappropriate equipment
7. Inoperable equipment:

    a) equipment inoperable when received due to:
        i. manufacturer's fault
        ii. fault in specifying or ordering
        iii. damage in transit
        iv. customs
        v. handling by an intermediate supply organization
        vi. inappropriate facilities for use
        vii. lack of user experience
        viii. lack of tools and knowledge of tools needed

    b) equipment unusable because necessary consumable supplies or accessories are unavailable

    c) equipment unusable because donors have failed to evaluate local conditions

    d) equipment which has become defective and unusable:-
        i. awaiting service agents
        ii. with no source of commercial servicing
        iii. awaiting in-house servicing repair
        iv. because poor quality equipment was ordered
        v. but could be restored cheaply and easily.

Source: WHO, 1987 Inter-regional Meeting on the Maintenance and Repair of Healthcare Equipment, Nicosia, Cyprus 24-28 November 1986 [2]

In-house maintenance units

The public sector may have several units, in various ministries, with some maintenance skills and providing a service to the health sector. Such arrangements have not been very successful in providing the necessary technical coverage. *Bloom and Temple-Bird* discovered in 1988, that a number of countries were starting attempts to strengthen their Ministry of Health maintenance teams.[51] These initiatives, often supported by international donors, ran into a number of problems.[5] In some cases, it was difficult to recruit personnel for training and, once skilled, to retain them in the public sector. There are many examples of low level technicians deployed in poorly equipped workshops with very little administrative support. The effectiveness of such units is low. It is now recognised that training basic-level technicians, by itself, only makes a limited impact on the state of equipment if graduates are not integrated into a functioning maintenance service. Establishing an effective in-house maintenance capacity requires substantial financial and administrative support over a number of years, and must take place within the context of a comprehensive equipment management service.

2.3.8 Weak Industrial Sector

One reason why developing countries find it so difficult and expensive to keep equipment in operation is the small size of their industrial sectors. In this situation, a firm (or health facility) which uses imported technology must, itself, develop all the necessary skills for supporting equipment, or identify an alternative source of specialized inputs. It is often difficult to obtain a specific component or to find an engineer with a particular skill when required.

These problems are made worse by the small size of many national economies, which provide companies with little incentive to develop the capacity to maintain complex machinery or make spare parts. Governments have not pursued helpful initiatives, such as: increasing regional integration and reducing the variety of imported technologies (standardizing), which would make it easier to establish a stable market for spare parts, after-sales services, and locally manufactured items (Chapter 9).

National and regional technical capacity
Making effective use of imported equipment is not exclusive to the health sector. Similar issues have been raised in studies of the capital goods industry in SSA, for example. A common finding is that imported equipment was being utilized at well below full capacity.[6,7] Underlying the problems was a lack of both administrative and technical skills, which limited the ability to utilize imported technology effectively and for innovation within the capital goods industry.

The *United Nations Conference on Trade and Development (UNCTAD)* reports that a 1991 survey of 20 least developed countries (LDCs) found manufacturing capacity underutilization was a widespread phenomenon.[52] Half the countries had manufacturing capacity utilization of less than 20%, with the rest at 20 – 40%. One major contributor to this situation was management inadequacies such as lack of maintenance of the equipment and machinery. Economic performance of LDCs, measured in terms of growth of real output, had deteriorated during 1990 – 1993 in contrast to the marked improvement in developing countries as a whole. Obviously there is great diversity in a region the size of SSA, for example by 1993 Botswana had graduated from the LDC category.[52] But in 1995, *Hewitt & Wield* looked at selected indicators of economic growth and export performance, and found that African countries (with the partial exception of South Africa) look very weak on all indicators.[53] The last decade has seen many reversals; some African countries achieved substantial annual growth rates of 'manufacturing value-added' in the early 1990s, but by 2000 the overall trend for SSA was a slow down.[54,55]

Indicators for levels of technological development

Healthcare technology is being used in many countries where the level of technological development is quite low. The *United Nations Industrial Development Organization (UNIDO)* calculates that SSA (excluding South Africa and Namibia) accounted for a little over one percent of production of non-electrical equipment by developing countries.[56] Zimbabwe accounted for over a third of the regional total.

The smallness of the capital goods industry in SSA is demonstrated by the very small number of people it employs. In the early '80s, only 10 countries of the region had more than 5,000 people working in the capital goods industry. Only Zimbabwe, Nigeria, and Kenya reported more than 20,000 employees in this sector. These totals included trained personnel as well as unskilled labourers.[56] This serves to illustrate how small the pool of people with direct experience of the selection, operation and maintenance of complex equipment may be.

The total number of qualified technical workers in the region is very small. In the 1970s there were only 14.1 scientists, engineers, and technicians per 10,000 people in Africa.[56] This was less than one third of the numbers available to Asia and a tenth of those in developed market economies. There has, of course, been an expansion in training programmes during the intervening years. By 1990, the average for developing countries had risen to 90 scientists and technicians per 10,000 people; although there were no statistics for Africa as a region, Zambia and Botswana had 44 and 12 respectively.[57] However, there is still a shortage of people who combine technical qualifications with substantial practical experience (see Chapter 7).

2.3.9 Poor Manufacturers' Support

To ensure that equipment sold to clients continues to function effectively, a wide variety of after-sales services are required. Exporters provide such coverage in the more affluent countries in various ways: subsidiary companies are established; agreements are signed with other manufacturers, or with local agents to provide the necessary service. Suppliers of equipment frequently provide their customers in industrialized countries with a full range of after-sales support. They usually do not give this kind of service to purchasers in developing countries.

The issues in SSA

Many countries of SSA do not provide a large enough market to warrant full after-sales coverage from the manufacturer. At the same time, neither the private sector nor the public health services have the capacity to undertake the necessary maintenance on their own. Contracted maintenance services are often more expensive and of inferior quality to those in the manufacturer's home country. Lack of after-sales support can mean equipment is out of use for months. An assessment of the service agreements on offer in Zimbabwe, for example, revealed that local firms could not provide reliable coverage at a reasonable cost.[58] This strengthened the case for the development of an in-house maintenance capacity. On the other hand, the problems that arise from poor contact with the manufacturers are much in evidence; there is little performance feedback, no control of quality of operation and servicing, and an absence of specialized back-up services. Thus, in addition to creating an in-house maintenance capacity, it is necessary to establish appropriate links with manufacturers for back-up services.

The role of the manufacturers

UK manufacturers interviewed by *Bloom & Temple-Bird* reported that they provide a relatively low level of after-sales service to clients in SSA.[3] Only a minority of the companies have subsidiaries in the region or strong commitments from their representatives to provide maintenance services; even in these cases, it was not possible to assess the quality of the services provided. The remainder of the firms provided only the support that they could offer whilst remaining at their UK base. Many manufacturers reported that they receive almost no feedback on the functioning of their equipment or the services provided by their representatives, and receive very few requests for support. After-sales service largely consists of answering queries rather than providing technical services. In general, these questions originate from individuals rather than from MOH maintenance services. In fact, there seems to be little organised contact between public sector maintenance teams and the manufacturers. Regardless of these issues, most manufacturers supply to countries whether or not they have a representative there (Chapter 9).

2.3.10 Piecemeal Attempts to Improve the Situation

With such a wide range of factors affecting the functioning life of equipment in developing countries, governments and donors have tried different initiatives over the years to address the situation. These initiatives have not proven wholly successful, mainly because there are so many factors contributing to the problem and approaches taken tended to address only one or two of them at a time. The type of initiatives have been: to buy new equipment, without providing after sales support; to provide spare parts with new equipment, without training technicians in its repair; to train maintenance staff, without improvements to workshops and tools so that new skills can be applied; to build workshops, without development of adequate budgets to support a maintenance service; and so on (Chapter 10).

On reflection it can be seen that such piecemeal approaches were bound to fail, since the initiatives would founder on all the other contributing factors that had not been addressed. In other words the situation as a 'whole' was never addressed by governments or external support agencies. This would appear to be due to a lack of understanding of the sector and its multiple problems, and the many different people involved in the life of equipment who work in isolation on equipment issues.

2.3.11 Many People with a Role to Play

Range of health service providers

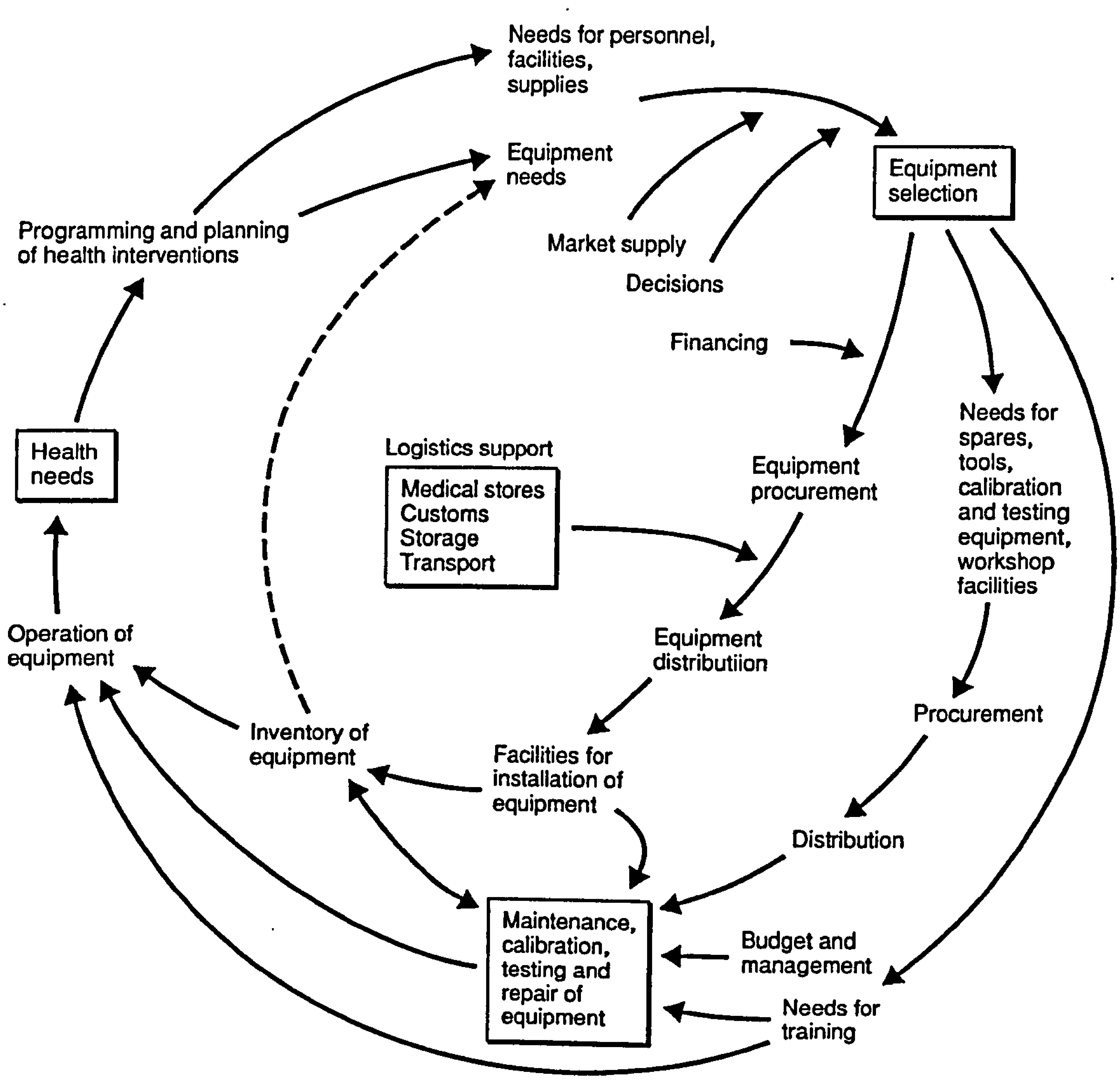
In most countries there are several health service providers – government, mission, mining/industrial, and private authorities. Even public sector facilities can be run by a number of ministries, such as health, local government, and defence. Ministries of Health have found it difficult to manage the multiple interlinking equipment factors, but the task of raising awareness and co-ordinating between many health service providers is an even bigger task.

Personnel within health service organizations

Decisions are made every day affecting equipment life. They are made by a wide range of people who work in many different sections of health service organizations (finance officers, stores controllers, medical staff, procurement officers, personnel staff, planners, aid co-ordinators, trainers, equipment users, facility administrators, etc). Commonly their decisions are made independently, with little co-ordination. In addition, decision-makers invariably do not have to live with the consequences of their decisions. For example, the person selecting equipment does not have to maintain it; the person allocating the maintenance budget does not have to run the maintenance services with inadequate resources; the person ordering supplies does not have to operate equipment when consumables run low (Chapter 6).

Figure 2.13 shows the complex interplay of decisions and activities that affect the life of equipment. Not only is it common for the factors affecting equipment to be uncoordinated, but the decisions made are governed by existing administrative rules and regulations which may prohibit the rational management of equipment. It is apparent that equipment management cannot be divorced from the policies and practices of the health service as a whole. Ministries of Health often do not have an effective system of healthcare technology management; most of them have not yet established a unit to take overall responsibility for this area.

FIGURE 2.13: Interlinking decisions and activities which affect the life of equipment



Source: WHO, 1987 Inter-regional Meeting on the Maintenance and Repair of Healthcare Equipment, Nicosia, Cyprus 24-28 November 1986 [2]

The range of other players involved

Successful management of healthcare technology issues requires the active support of a number of ministries, for example ministries of Works or Construction may take part in its maintenance. Others with a role to play are members of the local private sector including subsidiaries of international suppliers, agents of foreign manufacturers, and local companies with expertise in sales, maintenance, and production.

2.3.12 A Little Known Field

Even though the crisis facing healthcare technology is apparent to the technical staff dealing with it, this is a little known field. The general public is aware of the need for doctors and nurses, and has become aware of the need for equipment through local fund-raising initiatives. However, little conscious thought is given to the need to maintain this equipment or that there may be public sector maintenance personnel employed specifically for this purpose. Even within health service organizations, it is common for medical staff and administrators to resist the need to deal with things 'technological'. Co-ordination of the factors affecting equipment definitely requires an input of technical knowledge; but many countries are short of managers per se let alone technical managers. This is also true of donor organizations; thus equipment projects of large monetary value can be handled without any technical input or expertise.

2.4 CONCLUSION

Health service providers have to deal with a wide range of different types of equipment (healthcare technology). But, the *World Bank* reports that in developing countries health facilities are short of adequate quantities of functioning equipment for the effective delivery of services, and their stock is old.[8]

An annual expenditure of US$ 129 – 246 million on medical equipment in SSA in 1995 (depending on the calculation used) constitutes a significant investment for the region. But this translates to a relatively low level of expenditure per country, thus it is important to use available resources well. However, problems have been identified at every stage of use of imported healthcare technology. For example: unnecessarily expensive items are chosen, and may be inappropriate to the harsh environment; inadequately trained operators cannot use equipment safely and effectively; items stand idle without consumables or due to minor faults, and deteriorate quickly without adequate maintenance. As a result, a large proportion of expenditure on equipment yields little benefit. A range of activities must be considered holistically if healthcare technology is to function successfully. Therefore, one perspective from which to approach healthcare technology is to view it as a *Technological System* with its many sub-systems.

One reason for the poor state of equipment is lack of management – a *WHO* international conference agreed that many health services have little capacity to plan and manage its use.[2] Some health service providers have been more successful. For example, both Zambian mining hospitals (*Temple-Bird*) and Kenyan private hospitals (*World Bank*) have been able to keep equipment in running order at a time when the public sector has experienced great difficulty.[8,59] This is due to improved management techniques, and recognition of the importance of financing and maintenance. It is possible to see that the management capabilities and procedures of institutions will be important. Therefore, another perspective from which to approach healthcare technology is to view it as an *Institutional Organization Issue*.

Poor management of healthcare technology is common in developing countries, but also arises in industrialized ones. However, industrialized countries have the choice of equipment designed for their needs and receive good technical support from equipment manufacturers close at hand. Developing countries have to cope with equipment that may be inappropriate, and invariably receive inferior quality after-sales support. Even though the problems for healthcare technology are much the same as with the import and use of any other machines, good technology transfer principles have not been applied. Frequently, the policies and practices of external support agencies have exacerbated the situation. It is possible to see that healthcare technology is facing a very different situation to that in industrialized developed countries. Therefore, another perspective from which to approach healthcare technology is to view it as a *Development Issue*.

Thus in my Thesis, I develop the three perspectives and investigate how the relationship between them is of importance for success in this field. There is an urgent need to find strategies to strengthen the capacity to manage healthcare technology in Sub-Saharan Africa. Chapter 2 argues that key issues need to be addressed to improve the sustainability of healthcare technology in SSA, such as adequate finance, appropriate designs and support from the private sector, a coordinated and aware approach from external support agencies, strong technical capacity in the region, improved organizational capabilities within the institutions involved, and an understanding of the holistic approach required. This analysis provides the background to my key research question:-

Q1 *How can the sustainability of the healthcare technology sector be improved in SSA?*

CHAPTER THREE: METHODOLOGY

My main concern is how the sustainability of the healthcare technology sector can be improved in Sub-Saharan Africa. In order to research this field and attempt to answer my research questions, I have pursued a number of methodological practices:

i) systemic, ie. the analysis of a whole system and the sub-sets of the system;
ii) case studies, ie. the study of the healthcare technology sector in a variety of countries;
iii) modelling, ie. using a heuristic framework as a tool;
iv) multi-method data gathering fieldwork;
v) focusing on certain aspects of the data generated by the application of the tool – experience has shown that common recurring themes cause the greatest constraints;
vi) literature review, ie. the use of a range of literature to underpin my theoretical approach which considers healthcare technology from three perspectives.

3.1 A SYSTEMIC APPROACH

During my career working as an engineer in the health sectors of SSA, I was exposed to the problems faced with healthcare technology. On return to the UK, I began research into this problem. The idea of considering the 'holistic package' of inputs required to manage the sector and successfully transfer healthcare technology was developed. The research led to the publication of a book (with Bloom) in 1988, which highlighted the problems of importing technology into SSA. A Healthcare Technology Package system was used to analyze the sector.[3] The HTP system was used as a modelling framework for this Thesis. The entire system and set of sub-systems is presented in Chapter 4.

I have used this modelling framework over many years undertaking consultancy and research work in developing countries, in order to see the whole picture when considering the healthcare technology sector. In particular I applied it in the three country case studies which represent the field work for this Thesis (Section 3.2). Thus in each country, a systemic analysis was undertaken and data was gathered regarding performance in all the sub-sets of the system.

As *Blackmore and Ison* state a systemic (holistic) approach to investigation and action helps to make sense of complex and messy situations. The process of considering what systems and sub-systems are relevant to a situation can help to draw out those aspects that have been omitted or should be added. Thus, the 'systems thinking' involved in this methodology allowed me to consider a number of partial or simplified views of a situation in order to better understand the whole situation.[60]

3.2 CASE STUDIES

Having already developed a modelling framework to analyze the healthcare technology sector (Chapter 4), I applied the model to real country situations to see if it would be a useful 'tool'. I chose in-depth case study research so that each country would provide a comprehensive explanation and understanding of my Thesis research questions (Section 1.3.2). As *Thomas* explains, using case studies was an appropriate methodology since I had several possible 'units of analysis' at different levels whose characteristics and interrelationships could be studied within the healthcare technology sector as a whole.[61]

The method used to apply the modelling framework during a country study was changed and developed over time (Section 3.3). Initially, the modelling framework was used in Zambia in an informal way, to ensure a more holistic approach to analyzing the problems with the healthcare technology sector. This was a pilot case study which, as *Yin* describes, enabled me to obtain conceptual clarification for the research design, and to refine my data collection plans with respect to both the content of the data and the procedures to follow (Section 3.3.1).[62]

Subsequently, the modelling framework was presented to a regional meeting organized by the *WHO and the Danish International Development Agency (DANIDA)* in Arusha, at which it was recommended that the next stage would be to apply it in full in a single country.[63] The Ministry of Health of Botswana decided to undertake the study as part of its efforts to strengthen its management systems, with full-time assistance from me. The aim of the study was to look formally at every component of the Healthcare Technology Package and all the institutions involved. In this way it would be possible to understand how each sub-system was organized in Botswana, and identify problems to effective functioning and constraints to change.

The experience in Botswana enabled me to develop 'How To' guidelines for undertaking such a study. These guidelines allowed the Ministry of Health and Social Services (MOHSS) of Namibia to undertake a similar study themselves with periodic assistance from me. This work took the process a step further because besides analyzing the equipment situation, it was possible to work with the MOHSS to formulate equipment policy as a result.

Thus I applied the modelling framework to the case study countries in a particular way. Firstly, by looking at the healthcare technology sector in three countries – Zambia, Botswana, Namibia – which are different to each other in a number of features (size, economy, population, etc – see Section 5.1). Secondly, by studying the equipment sector in these countries at three separate times – Zambia in 1990, Botswana in 1992, and Namibia in

1997 (Section 3.3). Also since I continued to work in all three countries, I monitored on-going changes over the past decade (Section 3.3.4), and used the research to assist my work.

By choosing three countries, I have been able to show different aspects of national healthcare technology sectors and analyze the mix of similar and contrasting results obtained. As *Yin* states, I therefore employed a multiple-case replication design.[62] In order to conduct the case studies, I used evidence from six sources requiring different methodological procedures: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (Section 3.3).[62]

As *Thomas* states, a case study investigation is really a framework for research rather than a specific 'method'.[61] Within that research framework, I was able to use a combination of methods which analyzed people (*Woodhouse*), paper (*Barrientos*), organizations (*Roche*), and data (Mayer)[64-67] Thus I used different field procedures and multiple sources of evidence as part of my case study methods (*Yin*).[62] Within each case study I had to learn to integrate real-world events with the needs of the data collection plan, for example the attempted coup in Zambia affected data collection. I had to find coping strategies and adapt to: interviewees' schedules and availability; resistance to co-operation; lack of pertinent documents; ability to travel and gain access; my intrusion into the world of the subject, etc.[62] It was important to realize that there was more than one way to gather data, for example physical inspection of equipment versus study of documents for indicative data.

3.3 MODELLING TOGETHER WITH MULTI-METHOD DATA GATHERING FIELDWORK

The HTP system developed incorporates the two conditions of modelling which *Thomas and Chataway* state are necessary to make a model 'valid', namely:

- it provides a simplified description of what happens in order to abstract what are thought to be essentials;
- it represents an 'ideal' relevant to the sector involved.[68]

Thus the use of the modelling framework in three countries enabled me to discover and learn about the reality of each sub-system, whilst also imagining what a sustainable system might look like.

I applied this heuristic tool during the case studies and it enabled me, and those in the countries involved, to investigate their own healthcare technology sector and discover things they did not know. A great deal of data was generated (see Chapters 5 – 10) and much of it was a surprise to the institutions involved.

Undertaking three country case studies at three different times over a decade provided a learning process, and the experiential development allowed both the modelling framework to be refined and its application method to change and improve from one country to the next. The learning process is on-going; the experience from these countries helped me in my subsequent work and will offer assistance to the development of ways to improve sustainability for other countries in the future. The steps in the learning process are presented in this Chapter as follows:

* an informal approach used in Zambia as a pilot case study in 1990 (Section 3.3.1);
* a structured approach used in Botswana in 1992 (Section 3.3.2);
* the application of 'How To' guidelines for a structured approach in Namibia in 1997 (Section 3.3.3).

The modelling process incorporated detailed data gathering fieldwork in-country using different methodological procedures[62], such as:

- documentation: study of items such as files and reports of organizations, government publications, reports and data, contracts;
- archival records: study of items such as budgets, inventories, maintenance and work records, organogrammes, statistics;
- interviews: both open-ended and structured interviews (using questionnaires) with various levels of staff in a variety of government, private, and independent institutions (see Tables 3.1 – 3.9 in Annex I);
- interviews: formal surveys (using questionnaires) of agencies involved in the supply of healthcare technology;
- direct observations: field visit observations of staff in health units, maintenance workshops, teaching institutions, and private sector facilities, as they went about their working practices (Tables 3.1 – 3.9);
- direct observations: surveys of equipment through physical inspection (Section 5.1);
- participant-observations: holding workshops and seminars for discussion and feedback, as well as working alongside staff;
- physical artifacts: outputs resulting from the work, such as inventories produced, policies written, budget analyses undertaken.

3.3.1 Informal Approach in Zambia - a Pilot Case Study

My involvement in a review of the hospital equipment sector of Zambia in 1990 [69] (together with health management expert, Mr B.Haddon) on behalf of the Overseas Development Administration (ODA) of the UK Government, enabled a study to be undertaken informally according to the developed framework, as a pilot.

The modelling framework used

The HTP published in 1988 identified just nine sub-systems: i) management, ii) financial planning, iii) selection, iv) procurement, v) operation (both getting equipment going, and continued use), vi) maintenance, vii) personnel and training, viii) technology assessment, research and development, and ix) local production. However, the areas studied are the same as the final version of the HTP described in Section 3.1 but simply labelled differently. There were four categories of 'players' who deliver these different components, as in the final version. But the need to gather specific relevant background statistics on health, the economy, industry, education, etc, within a country had not yet been made explicit.

However time restrictions of the Zambia study and the priority of the client to concentrate on rehabilitation possibilities for equipment, meant only components i-vii (above) were studied, and technology assessment, R&D, and local production were omitted in that pilot case study. Even here, however, significant data were gathered.

Phase I : Field work

All aspects of Zambia's hospital equipment system (though focusing on the larger hospitals) and all types of medical equipment and some hospital plant were reviewed. It seemed appropriate to try to organize the study along the lines of the modelling framework.

Data were gathered and analyzed regarding the present state of equipment, and progress with seven of the HTP system components in government and non-government health sectors. Four basic categories of institutions involved in the sector and background national statistics were also studied. The study methodology was not formalized, the researchers simply following the modelling framework.

Meetings were held with senior MOH staff with responsibility for this field. A number of visits to health facilities and institutions were undertaken. Equipment operators, maintainers, managers, and relevant support and administrative staff were interviewed in order to obtain their perspectives. In addition, relevant documents were studied.

To assess the condition of medical equipment and plant, some 1500 individual items were examined at six government hospitals of assorted levels around the country; for comparison two mine hospitals were also visited (see Table 3.1 in Annex I).[70] The pilot study concentrated on laboratories, operating theatres, sterilizing departments, x-ray units, premature baby units, kitchens, laundries, steam plant, and workshops. Wards and other facilities were also examined in less detail. To gain information on the state of equipment and the capacity to use and maintain it, additional training and maintenance institutions were visited (Table 3.2 in Annex I).

Table 3.3 (in Annex I) details additional visits made and discussions held with donors, private sector equipment supply/support companies, mission and mine organizations, two parastatals, and a donor-supported project. Further visits were curtailed due to an attempted coup.

Phase II : Analysis of data

The data collected were analyzed and tabulated. A great deal was found to be previously unknown. Using the modelling framework to organize it according to the seven components studied and the different institutions playing a role in the equipment sector, proved very useful. A report was drafted that provided a situation analysis, made recommendations for addressing the constraints identified, and detailed an equipment renewal programme, enabling a plan to be presented to donors for joint funding.

3.3.2 Structured Approach in Botswana

Following the presentation of the modelling framework to the WHO/DANIDA regional meeting in Arusha[63] (Section 3.2), the Botswanan MOH decided to ask me to help them undertake the study as part of its management strengthening programme supported by the Norwegian Agency for Development (NORAD). I carried out the work as a research project based at the Institute of Development Studies, with financial support from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and ODA. Thus a more structured formal approach was used in Botswana in 1992.[71] It comprised a number of phases, as follows.

The modelling framework used

The study in Botswana used the same HTP with nine sub-system labels as for the Zambian pilot study (Section 3.3.1). The four categories of players who deliver these different components and the areas which provide background context, were investigated.

It was during the Botswana country study that it became clear that the gathering of statistics detailing health, economics, education, and industrial parameters was crucial. Study of the health sector is required because health services develop, study of associated sectors provides the bigger picture, enabling the healthcare technology sector to be contextualized (Chapter 5). Also, many of the institutions involved in technology management are very complex and need untangling (Chapters 6 – 10).

Phase I : Preparation

Prior to arrival, I reviewed background material on the health sector of Botswana, developed draft questionnaires and inventory forms, and requested the MOH to identify a counterpart researcher, a Steering Group, and nominate a senior officer through whom the study would be organized.

Phase II : Introductory visit

An initial visit was made for consultation with MOH officers. I met my counterpart and assistant, Mr Richard Mhiti – a Senior Technical Officer in the Medical Equipment and Maintenance Services (MEMS), and we formed the Core Study Team (of 2) which was responsible for the project. The senior officer we reported to was the Assistant Director of Technical Support Services in the MOH (a NORAD officer). A broad based Steering Group was established with senior officers from the nine MOH divisions of most relevance to the study.

As the leader of the Core Study Team, I ensured we reviewed documents and held meetings with people involved in different aspects of the planning and management of medical equipment in the MOH and MEMS, as well as staff at the central referral hospital. Written submissions were made by various parties. The discussions covered:

* organization of healthcare technology management;
* problems identified by users, planners, managers, and technicians;
* plans for development of the equipment management system;
* MOH development plans with relevance to healthcare technology.

As a result, the Core Study Team was able to draft a work programme which was finalized after review by the Steering Group.

Phase III : Field work

Although the analysis of equipment management was organized according to nine components of the HTP, four broad categories of institutions involved, and background data collection, it was felt that information could not necessarily be gathered in this way. Research/fieldwork activities were undertaken as follows:

* review of the MOH medical equipment management system;
* review of the primary and referral hospital upgrading projects;
* district hospital diagnostic studies to be undertaken by the team;
* review of the management of medical equipment for primary healthcare;
* review of the development plan for MEMS;
* study of other public sector bodies with responsibility for management and maintenance of healthcare technology;
* visits to selected users of imported non-medical equipment;
* review of R&D and local production;
* review of training institutions and bodies;
* visits to other relevant bodies;
* visits to facilities of other health service providers.

Over a four-month period, the Core Study Team undertook all interviews and visits. Equipment operators, maintainers, managers, and relevant support and administrative staff were interviewed to obtain their perspectives on the state of equipment and equipment management. During the diagnostic study of district hospitals, they compiled an inventory of the equipment examined. For these health facility tours a larger team was convened, comprising:

biomedical engineer, core member (myself)
technical officer, core member
planning officer
hospital management officer
supplies officer
Central Sterile Supplies Department (CSSD)/theatre superintendent.

The condition of medical equipment and plant was assessed at four government district hospitals, one mission hospital and one mine hospital. 815 items of medical equipment were examined in detail by the study team mainly concentrating on laboratories, theatres, sterilizing departments, x-ray units, maternity/labour departments, dental clinics, stores, and incineration facilities. 98 items of plant were examined in detail from the following areas: kitchens, laundries, mortuaries, generators, hot water supply, refrigeration and air-conditioning plant, and extraction facilities. In addition, equipment issues and problems were discussed at the two central referral hospitals, one defence force clinic, and several primary healthcare divisions (see Table 3.4 in Annex I). To gain further information on the state of equipment and the capacity to use and maintain it, additional maintenance and training institutions were visited (Table 3.5 in Annex I).

To understand how the equipment sector worked, interviews were undertaken with: donors, private equipment supply/support companies, hospital management consultancy firms, companies (public and private) utilizing specialized equipment successfully in the same environment, and several ministries (see Table 3.6 in Annex I), as well as many different divisions within the MOH itself (Table 3.7 in Annex I).

A survey of equipment supply companies was undertaken by sending a questionnaire to companies on the Department of Supply's (DOS) list of tenderers for the MOH, with questions concerning resources, support services offered, and the take up by the MOH; 24 out of 48 responded.

Phase IV : Analysis of data

The data collected were analyzed, tabulated, and organized according to the background statistics, four different categories of players, and the nine HTP components. I drafted a report that offered a discussion of the issues involved, provided a situation analysis, and made recommendations for addressing the constraints identified. The draft report was made available for comments from the Botswanan authorities and key personnel involved in the study, and then finalized. A great deal of previously unknown data was discovered, with many surprising findings and anomalies. The MOH disseminated the information, and started a process of acting on the lessons learnt, identifying possible approaches to the problems identified, and implementing the recommendations. Subsequently the report was published by the WHO.[71]

3.3.3 Application of 'How To' Guidelines for a Structured Approach in Namibia

The experience of implementing the structured methodology in Botswana enabled me to develop 'How To' guidelines for undertaking such a study. The Finnish International Development Agency (FINNIDA) provided support to the Ministry of Health and Social Services (MOHSS) of Namibia, so that they could apply these guidelines in 1997 with assistance from me.[72,73] I also provided subsequent support to enable the MOHSS to take the results of this work further. As the approach was slightly different and the aim of the work was to achieve additional outputs, the phases used were modified to the following.

The modelling framework used

During the Namibian country case study, it was decided that so much information is generated when studying the original HTP components: (v) operation (getting equipment going, and continued use), and (vii) personnel and training, that they should be divided. Thus the HTP was changed to 11 components as described in Section 3.1.

Phase I : Introductory visit

A first visit was undertaken so that I could consult with the MOHSS and FINNIDA and meet senior officials. I reviewed background material and held discussions with officials involved in the planning and management of healthcare technology at various levels and from different organizations to obtain an overview of key equipment issues and constraints. Tables 3.8 and 3.9 (in Annex I) detail the visits made to the central ministry, various health facilities (central, regional and district), and maintenance organizations (public and private). The discussions covered:

* development budgets and upgrading of health facilities;
* maintenance staffing – a national network;
* maintenance of plant.

I then drafted a work programme together with key senior officials.

Phase II : Means of implementation

The MOHSS established a Task Force which was comprised of eight senior officers from the following divisions:

Planning and Human Resources Directorate
Clinical Engineering Division, Windhoek Central Hospital
FINNIDA's Health and Social Services Sector Programme.

I provided a conceptual framework for the Task Force to apply as "How To" guidelines. It contained i) a Briefing Document and ii) a Situation Analysis Format, based on the experience of the study undertaken in Botswana. The Situation Analysis Format followed the modelling framework previously developed, and was divided into sections reflecting the background statistics, four different categories of players with a role in the equipment sector, and 11 HTP components. For each section, the Task Force was given information on the various issues involved, the kinds of information required, and the kinds of activities that should occur. Then they were presented with a series of questions to answer to prompt the process of analyzing the situation and problems in Namibia.

Phase III : Field work

The Task Force followed this conceptual framework, and thereby undertook a situation analysis by gathering the data required and answering queries in the Situation Analysis Format. The information gathered fell under the categories of "the situation as it is now", "constraints and problems", and "draft proposals". They used their own experience; documents, standards, and guidelines; interviews and discussion; hospital visits; etc. I filled gaps and undertook follow-up visits and investigations. I sought to identify those procedures and regulations which create constraints to the rationalization of the healthcare technology sector.

Phase IV : Analysis of data

The data collected was analyzed, tabulated, and organized according to the layout of the framework and situation analysis format. I drafted a report that offered a discussion of the issues involved, provided an analysis of the situation found, and made preliminary recommendations for addressing the constraints identified.

The "Situation Analysis and Problems" identified by the Task Force was presented to a wider audience of the many people and institutions involved in healthcare technology management at a national workshop.

Phase V : National workshop

A 3-day workshop was held with participants from MOHSS central and regional offices, health facilities, Department of Works, equipment supplier companies, and donor agencies.

The participants came from the many different divisions that affect the life of equipment: technical services, medical, nursing, supplies, administration, finance, planning, human resources, etc. I acted as a facilitator for the proceedings.

Working groups were used to study the findings under the 11 components of the HTP. Their task was to discuss and brainstorm around these issues, and come up with functional alternatives to the problems. Working Groups reported to plenary sessions where their recommendations were reviewed. From the presentations, specific points were identified as key issues. New Working Groups were chosen to take these issues further, refine and expand them, and develop work plans for the implementation of the changes agreed. These were presented and agreed by plenary session. The output from the workshop enabled the Situation Analysis document to be finalized, and the work plans informed the subsequent policy formulation process.[73]

Phase VI : Policy formulation and further activities

As a result of analyzing their equipment situation, the MOHSS in Namibia was able to proceed with the formulation of equipment policy. Once the constraints had been identified, it was possible to move forward and base equipment policy on a fuller understanding of equipment management issues.

Over a 2-week period with my assistance, the Task Force met to develop: the structure of the policy document; its goals, objectives and strategies; and statements of intent. The recommendations for change from the national workshop were fed directly into the policy document by being turned into statements of intent. It proved useful to structure the Policy document along the lines of the 11 components of the HTP framework, thereby automatically giving sections under which statements of intent could be organized.[74] Over a further period, it was necessary to develop an implementation plan for the policy, as well as calculations for the cost implications of the major initiatives suggested.

The formulation of an equipment policy which advocates changes to address constraints requires major policy changes. Thus, it was necessary for a number of key issues to be taken forward by the MOHSS to relevant bodies for pre-approval (Ministry of Finance, Works, Public Service Commission, etc). The outcome of these discussions enabled the policy document to be modified and finalized.

For the Equipment Policy to work in practice, implementation procedures had to be written. Also, additional resources had to be identified and allocated, such as staff establishments, budgets, training scholarships. The research identified gaps, such as the lack of an equipment inventory, development plan, and budget; their importance led the MOHSS to develop them with my assistance (see Section 3.3.4 and Chapter 8).

3.3.4 Additional Work Visits in the Last Decade

This fieldwork was supplemented by later work visits to the three countries, which broadened my exposure to the healthcare technology sector, the changes taking place over time, and updates of data collected. It enabled me to reflect and apply the insights arising from my research to my consultancy work, and vice versa. Table 3.10 summarizes the activities undertaken.

TABLE 3.10: Supplementary work visits to the case study countries

Country	Date	Activity
Zambia	1992	* to identify appropriate equipment needs for the basic training of health staff;
	1994-2000	* multiple visits to develop a healthcare technology management system in three central referral hospitals;
	1999	* to develop a healthcare technology policy for urban health clinics in Lusaka.
Botswana	1995	* to develop equipping designs and guidelines for the national district hospital upgrading programme, and the primary hospital upgrading programme;
	1998	* to investigate their progress with the healthcare technology sector since the 1992 visit, as part of my writing and publishing of a Manual for policy-makers and health service managers in developing countries.[75]
Namibia	1999	* to develop with the MOHSS their equipment development plan and core equipment expenditure plan based on a newly taken inventory;
	1999	* to develop the healthcare technology management strengthening component of the Finnish support programme to the MOHSS.

3.4 FOCUSING ON KEY OUTCOMES

The different methods of applying the modelling framework in the three case study countries provided a full holistic analysis of the equipment sector. The use of the modelling framework as a tool produced much data in all areas: the background statistics, four different categories of institutions with a role to play, and 11 HTP components. From this experience it has been possible to identify common recurring themes which cause the greatest constraints.

With so much data, it is not possible to tabulate all the detailed technical findings in full. However Chapter 5 presents data on the state of the equipment sector in each country, including a summary of the findings for the 11 components of the HTP system (Section 5.2). As *Wield* explains, focusing within PhD research is not only a valid methodology but also essential.[76] Thus, it has been necessary to focus on certain aspects of the data generated, in order to concentrate on the five key overarching themes which I believe re-occur as constraints; these are:

a. the institutional framework available for delivering healthcare technology management throughout the country (see Chapter 6);
b. the strategies taken to train personnel and develop a national technical management capacity (see Chapter 7);
c. sufficient allocation of financial resources (see Chapter 8);
d. the technical support available from the private sector (see Chapter 9);
e. the role played by external support agencies (see Chapter 10).

Thus in this Thesis, I explore these five themes which dominate the sustainability of the healthcare technology sector. I relate these five themes to my Thesis Framework of three theoretical perspectives (Section 3.5). I study how these perspectives must all be achieved at the same time if there is to be success in this field, and if answers are to be found to my research questions.

3.5 LITERATURE REVIEW LINKED TO MY THREE THEORETICAL PERSPECTIVES

I argue that healthcare technology has to function as part of the bigger picture. Thus the theoretical approach I have taken to this research, is to use a Thesis Framework which gives me the opportunity to consider healthcare technology from three perspectives – all of which I believe have to be taken into account if management of the sector is to be improved. I review and make use of a range of literature throughout my Thesis, both published and grey materials (*O'Laughlin*).[77] It is not possible to review such a broad range of literature in full; instead I make judicious use of it to underpin my theoretical approach and illuminate the arguments (*Barrientos).*[65] In addition, I investigate the usefulness of the supporting literature, which relates to my three theoretical perspectives as follows.

3.5.1 Healthcare Technology *as a Technological System*

It is necessary to consider healthcare technology as a system, and take into account all the components required to import technology into the healthcare environment. I have identified specific areas to study: four areas of background statistics, four different categories of institutions with a role to play in the sector, and 11 HTP components. To successfully transfer all the components, the technological issues must be seen as a whole, and co-ordinated and managed within the context of the conditions in the country concerned.

Thus the literature I have used to illuminate the technological system are resources covering technology transfer and assessment, the healthcare technology sector in general, and general country data and statistics.

3.5.2 Healthcare Technology *as an Institutional Organization Issue*

Management is key to the handling of a complex network of activities and issues. Although management capabilities of individuals are important, the ability of institutions and bodies to undertake processes is essential. Thus humans and technology must be integrated with the organizational procedures of institutions to ensure the continuity of an institutional memory of technological issues.

Thus the literature I have used to illuminate the institutional organization issue are resources covering organizational learning, technical training, human resource development, and technology management.

3.5.3 Healthcare Technology *as a Development Issue*

The issues surrounding healthcare technology vary considerably around the world; healthcare technology in SSA faces a very different situation to that in industrialized developed nations. Management has to be effective in unpromising conditions. Thus any strategies must take into account these specific problems, and review the role of external support agencies and the influence of their development approach.

Thus the literature I have used to illuminate the development issue are resources covering the policies and practices of external support agencies, health financing in developing countries, trade influences and technology development, as well as general country data and statistics.

3.6 CONCLUSION

The starting point of my Thesis is the holistic modelling framework I developed in 1988, that allows the systemic analysis of the healthcare technology sector in any country. After refinement, it comprised 19 sub-systems necessary for investigating the healthcare technology sector: four areas of background statistics, four different categories of institutions with a role to play, and 11 HTP components (Chapter 4). Having developed this framework, it was necessary to apply my model to real country situations to see if it would be a useful heuristic tool. Thus through the 1990s, I used various methods to apply the modelling framework through multi-method data gathering fieldwork. Initially, the philosophy was used in Zambia (1990) in a less formal way as a pilot study. Then a structured approach was used in Botswana (1992), which led to the development of 'How To' guidelines which were applied in Namibia (1997).

In all instances, studying the sector generated a great deal of information – much of it previously unknown to the health service providers. In each country, it was possible to gather data in all study areas of the modelling framework. Presenting the findings according to this framework provided clarity and proved useful for the ministries of health in understanding their healthcare technology sector. In Namibia, analysis of the situation enabled the MOHSS to formulate equipment policy.

Undertaking three country case studies at three different times over a decade provided a learning process, and the experiential development allowed the modelling framework to be refined to its final form (Section 3.1), and the application method to change and improve from one country to the next (Section 3.3). I believe the learning process is on-going, and these countries' experience will assist in developing ways to improve sustainability for others in future. In fact, I have adapted the 'How To' guidelines and experience from Namibia to publish generic guidelines for health service managers in developing countries who wish to develop national healthcare technology policy.[75] It is based upon the systemic modelling framework developed, and the premise that only when health service providers have understood the information gleaned through undertaking such a Situation Analysis, will they be able to write relevant and appropriate policy based on concrete facts.

The analysis generated a great deal of interesting information. In Chapter 5, I present data on the case study countries, the condition of their equipment, and a summary of the findings for the HTP sub-systems. Then I focus on five key overarching themes – the institutional framework for delivering healthcare technology management, personnel development for a national technical management capacity, allocation of sufficient financial resources, the private sector technical support available, and the role of external support agencies – which I believe reoccur as constraints and dominate the sustainability of the sector. These key issues are presented in Chapters 6 – 10.

The theoretical approach I have taken in this research, is to use a Thesis Framework and consider healthcare technology from three perspectives (as a technological system, an institutional organization issue, a development issue) – all of which I believe have to be taken into account if management of the sector is to be improved. I review a range of literature throughout my Thesis to support the theoretical approach and arguments, and investigate its usefulness.

CHAPTER FOUR: A MODELLING FRAMEWORK FOR AN HOLISTIC APPROACH

Chapter 2 provided a description of the multitude of issues and problems facing the healthcare technology sector in developing countries, which first attracted my attention to this subject. It argued that key issues need to be addressed to improve the sustainability of healthcare technology in Sub-Saharan Africa, thus providing the background to my key research question:-

Q1 *How can the sustainability of the healthcare technology sector be improved in Sub-Saharan Africa?*

In order to address this overarching question, I use my first theoretical perspective (see Section 3.5) and take a *Technological Systems* approach. This Chapter presents the starting point of the research, and introduces the details of the Healthcare Technology Package analytical tool that I developed. It also looks at the usefulness of technology transfer and systems literature to illuminate this subject.

4.1 NEED FOR BETTER HEALTHCARE TECHNOLOGY MANAGEMENT

The conclusion from Chapter 2 is that one reason for the poor state of equipment is the lack of management of that resource – which arises predominantly from a lack of understanding and awareness of the complexity of healthcare technology and its environment.

Many developing countries have made considerable progress in improving healthcare provision to their population by implementing strategies recommended by WHO for the development of health systems based on primary heath care. However, health planners and managers often underestimated the importance of economically-conscious technology management within a health system. Although proper planning, acquisition, maintenance and use of healthcare buildings and equipment are essential for efficient, cost effective and quality care, this remains a neglected component of health systems organization and management, resulting in high wastage of resources, decreased quality of care, and ultimately hindering improvement of health status.

A major key to improving technology management in healthcare facilities at all levels is the strengthening of a healthcare technical service and related areas. Contrary to earlier beliefs, this requires not only technicians, tools, and maintenance workshops but also a complex system integrated into the overall healthcare management process (Section 4.2). Maintenance is primarily a management task and only secondly a technological one. Before health authorities develop an appropriate system for equipment management and maintenance with national impact, therefore, a variety of measures is needed, comprising policy development, organizational, administrative and, even, legislative change, designed and targeted training, and other components.

In order to keep an equipment service in running order, a substantial proportion of the purchase price has to be spent each year to cover running costs, maintenance, and depreciation. Health services in SSA may have to allocate an even higher proportion for this purpose than those in Europe or North America, since distance from manufacturers and smallness of market means little support is available. Each component of the package; the acquisition of information, obtaining spares, and the provision of maintenance technicians is very expensive. If decision-makers in the region wish to make health services available, they must allocate adequate funds. There may be substantial benefits to a more cost-effective organization of the equipment service.

At the starting point of this Thesis (late 1980s), the international community had only recently begun to address the problem of healthcare technology management in developing countries. In 1986, the *World Health Organisation* recommended that every country establish a healthcare technical service to oversee the management of its equipment.[2] However, there were no internationally agreed guidelines on how such a unit should function; nor would it be appropriate simply to copy what had been done in the industrialised countries. Consequently, it seemed necessary to develop a modelling framework for the formulation of strategies to improve healthcare technology management. Thus, I began research into this problem at the Institute of Development Studies, where I provided the technical and Dr G Bloom provided the health economics input.[3] The modelling framework developed and detailed in this Chapter, was applied in three country case studies over the subsequent decade as the field work for this Thesis (Chapter 3).

4.2 DEVELOPMENT OF THE MODELLING FRAMEWORK

I needed to find a way of understanding the complexity of the import and use of healthcare technology by health service providers in developing countries. It seemed appropriate to pursue 'systems theory' or 'systems analysis' – the title applied to theories which make assumptions about the nature of organizational structures (*Bowey*).[78] For example, experts such as *Checkland*, and *Buckley* have developed 'hard' systems thinking (means-end model) traditionally used for problem-solving in engineering, and 'soft' systems thinking (organic, socio-cultural) used for analyzing organizations.[79,80] Over many decades 'systems' has been recognised as an organizing concept in science. *Ackoff* explains that a system is made up of elements with the following properties:

* the properties or behaviour of each element in the system has an effect on the properties or behaviour of the whole system;

* no element has an independent effect on the whole, and each element is affected by at least one other element;
* the system cannot be divided into independent subsystems (elements).[81]

Thus, I needed to define the system and sub-systems relevant to the use of healthcare technology. There was no obvious model for structuring the healthcare technology sector in SSA. The situation in industrial countries, where there is a dense network of organizations with technical expertise, cannot be replicated. The strategies adopted must take account of the strengths and weaknesses of existing institutions (public and private sector). The problem lies with management of imported healthcare technology, 'imported' meaning both equipment arriving in a country from abroad as a purchase by the public or private sector or as a donation, and also the concept of 'importing' technology into the healthcare environment.

The successful adoption of any new technology involves considerably more than the purchase of a piece of equipment. As *Stewart* of the World Bank proposed in 1979, it requires a package of inputs.[82] The package may include, among other things, recruitment and training of people with relevant skills, establishment of a management system, creation of a capacity to keep up with new developments, and development of ability to adapt technology to local needs. When some elements are absent or inadequate, the result is costly and ineffective use of imported technology. This is the situation with healthcare technology in a number of countries. Thus I propose that the effective importation of technology into the healthcare environment would be aided by learning from good technology transfer principles used in other sectors, and considered as a 'technological system' with a series of sub-systems.

Hughes explains that technological systems contain messy, complex, problem-solving components. They are both socially constructed and society shaping. Among the components in technological systems are physical artifacts (such as equipment), organizations, scientific artifacts (such as literature, training and research programs), legislative artifacts (ie. regulatory laws), and natural resources (such as environmental factors).[83] The healthcare technology sector should also be considered as a 'complex system' since it is made up of many institutions ('actors') with a role to play. Such institutions are socio-cultural systems and examples of 'organized complexity', ie. the relationships between different elements of the system are more flexible and fluid than in a simple system because there are alternative behaviours open to each element, and inter-relations are increasingly dependent on the transmission of information (*Buckley*).[80]

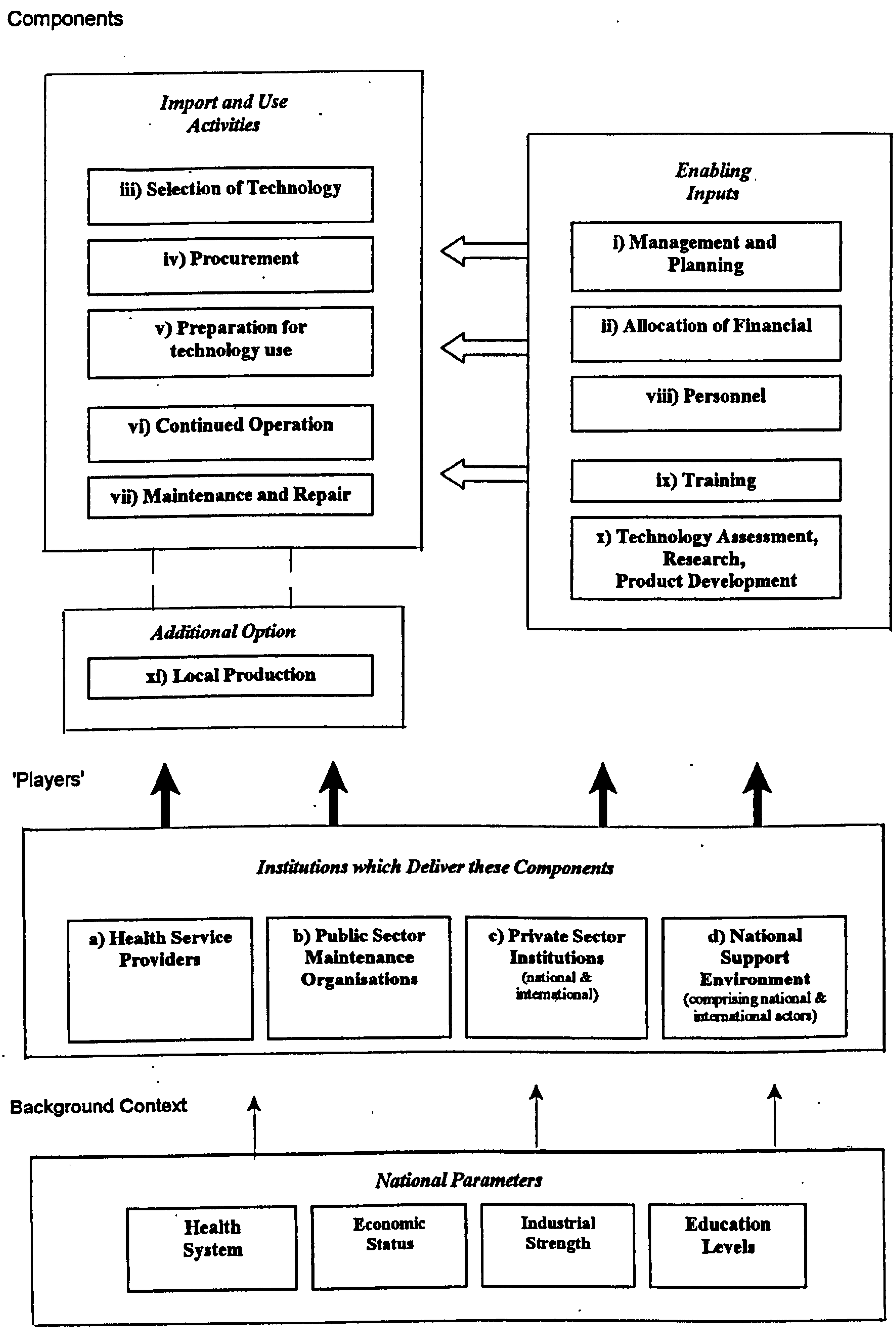
As reported in Chapter 2, decisions are made daily by a wide range of staff that affect the life of equipment. It is necessary to disentangle their activities and responsibilities in order to get a feeling for the 'whole' task. Thus, the approach taken to developing the framework was (1) to break the 'package' of necessary inputs into its component parts that cover all activities over the equipment's life-time. Then, (2) identify the institutions that could deliver these components, and (3) identify the background context in which the equipment is trying to function nationally.

Analyzing and 'unpackaging' the sector, led to the conclusion that the import and use of healthcare technology required five key activities: selection, procurement, preparing for use, continued operation, and maintenance. At some point a country may consider a sixth activity – the local production of spare parts or whole units rather than importing from abroad. In addition, it was determined that to be successful, the six activities require five enabling inputs: management and planning, allocation of requisite financial resources, the availability of personnel, with suitable training, and some capacity in technology assessment, research, and product development. These can be analyzed and constructed as component sub-systems, as shown in Figure 4.1.

In reality, these tasks cannot be differentiated so clearly as they are inter-related. For example, decisions on selection and procurement are dependent on the approach taken to maintenance. Nonetheless the package can usefully be broken into various elements for analytical purposes, whilst recognizing that the pieces fit together as a complex holistic system. For use as a modelling framework, sub-system order had to be considered. First the sequential order in which the activities occur in the equipment's life-cycle was considered, leading to i) management and planning, ii) allocation of financial resources, iii) selection of technology, iv) procurement, v) preparation for technology use, vi) continued operation, and vii) maintenance and repair. Then, other elements were considered which would be informed by the analysis of the first seven, leading to viii) personnel, ix) training, x) technology assessment, research, and product development, and xi) local production.

By analyzing the healthcare technology sector, it was also possible to identify the relevant sub-system actors providing the 11 components of the package, from the public and private sectors locally, in the region, or internationally. The preliminary analysis determined four categories of 'players': health service providers, public sector maintenance workshops, private sector institutions, and the national support environment, as further sub-systems. A study of these institutions shows how the different components of the package are delivered in any country. Background context concerning the country in which the equipment is trying to function is also required. Analysis of data on national health, education, economic and industrial parameters provides this, and forms four additional context sub-systems. Then, it is possible to consider in a systemic way different combinations of initiatives for any particular country, which will strengthen the capacity to use this technology.

FIGURE 4.1: The healthcare technology package (HTP) system with 19 sub-systems



Note: The original modelling framework published in 1988[3] started out with 9 component labels in the HT-Package which, over time, changed to the 11 labels shown above whilst keeping the contents the same.

As noted in Chapter 3, the structure of the system underwent some minor refinement over the course of its use during the PhD research. The HTP system published in 1988 presented nine component sub-systems because: components v) and vi) were combined as 'operation – both getting going and continued use'; and components viii) and ix) were combined as 'personnel and training'. By 1997, it was simpler to split these combined components into 11 sub-systems. Also, in the 1988 system, the four context sub-systems had not yet been made explicit. For ease of continuity throughout the rest of the Thesis, the format used is the final version with 19 sub-systems.

I take a *Technological Systems* approach to healthcare technology in this Chapter, and use the modelling framework for a discussion of the sub-systems – the 11 components of the package (Section 4.3.1), the four players involved (Section 4.3.2), and the four parameters for national background context (Section 4.3.3).

4.3 DISCUSSION OF THE SUB-SYSTEMS

4.3.1 <u>Eleven Components of the Package</u>

By breaking the Healthcare Technology Package into 11 component sub-systems, it is possible to study the problems, issues, and required activities that make up the complex whole. Although the components of the healthcare technology package are considered separately, it is important to remember that progress has to be made on several fronts at once. Each sub-system is a vast subject in its own right, so only the key points are discussed as an introduction from my experience and understanding of the field. Although developing countries are coping to differing degrees with each element, I mainly use negative points to illustrate the importance of managing each activity well. Aspects are covered in more detail in Chapters 5 – 10.

i. Management and planning sub-system

There is a consensus that the management and planning of healthcare technology has been inadequate in many countries of SSA, with little co-ordination of the various departments involved. For example, officers involved in selecting equipment do not consult those responsible for operation and maintenance. Adjudication of tenders and contract negotiation may take no account of the inputs required to keep equipment functioning. The *WHO* has stated repeatedly since 1987, that the result has been a high degree of waste.[1,5,26] It recommends that an integrated Healthcare Technical Service (HTS) is required nationally to oversee the provision of technical support to the health sector.[2]

Ministries of Health should establish a unit to head and manage the service. Substantial administrative resources have to be allocated to manage healthcare technology. The officer with responsibility for this service must have the capacity and the authority to ensure that all the components of the package are considered when decisions are made. Those responsible for operating and maintaining equipment have generally not had high status and have had access to few resources. The importance of the role of the equipment service has to be reflected in the pay of technicians, the status of the hospital technician/engineer, and the level at which the head of the equipment service is placed in the Ministry hierarchy (*WHO International Meeting*).[84]

It might seem obvious that to manage something it is imperative to know what that 'thing' is. However, the majority of ministries and institutions do not have equipment inventories, so do not have a clear idea of the quantity of equipment nor its state of repair. It is very difficult for them to plan for the future based on any real data (*Regional Committee of African Ministers of Health*). As little attention has been given to managing healthcare technology, ministries have been slow to formulate equipment policies, development plans, or other management 'tools' such as health service delivery goals, standard equipment lists, generic specifications, etc.[85]

Once these are developed, it is possible to formulate an equipment development strategy for acquiring the core equipment required and the resources to keep it operational. Attention can turn to more sophisticated technologies when these core needs have been met.

ii. Allocation of financial resources sub-system

Equipment ownership brings responsibility. In order to avoid the cyclical approach to funding which is costly and provides little benefit to patients (see Figure 2.8), replacement, maintenance and repair, and running costs for consumables, etc. must be funded. However many countries do not set aside sufficient funds for this, either due to national economic crises, annual estimates not being calculated based on actual requirements, or requirements being mis-calculated since there is no data regarding the existing stock.

Most equipment needs replacement within 5 – 20 years.[41] As *Bloom* discovered in 1989, in one country in SSA the value of the equipment stock was estimated, and replacement and maintenance was conservatively assumed to be 15 per cent of this. But as this required 12% of the recurrent health budget, only one-third of that amount was being spent.[86] This kind of calculation gives an idea of the magnitude of the problem being faced.

International experts suggest that maintenance costs alone are 6 – 15 per cent of purchase price each year.[87,88] But *Halbwachs*, for example, found that in Kenya the expenditure on maintenance was less than 1%.[89] This neglect resulted in various pieces of equipment ceasing to function in less than half the expected time, leaving health facilities short of the equipment required. Many pieces of equipment use consumable items (x-ray film, chemical reagents, recorder paper, filters, etc). Often hospitals cannot function effectively because they cannot obtain such inputs, many imported.[2,14,20,23-25] Recurrent budgets have many demands on them, and are used for drugs, general and medical supplies, food, fuel, and consumables such as light bulbs, etc. Thus, equipment needs get lost amongst the myriad daily requirements.

In order to arrive at more accurate estimates of requirements and avoid the wasteful cyclical approach to funding, health services require a core expenditure plan which estimates annual requirements over a period long enough to achieve the rationalization of the equipment sector – perhaps ten years.[3] Resources are needed to cover the life-time cost of the equipment.

Such an investment plan could yield several benefits. Continuity of basic equipment services would be adequately funded. Quantification of the real cost of sustaining an equipment service would inform decision-makers about the financial implications of a decision to buy, careful selection of equipment, and the need for establishing maintenance capacity. The longer-term purchasing policy could facilitate the process of standardizing equipment. Assurance of continuing demand might provide incentives to suppliers to provide better back-up services. A core purchasing plan could, also, provide a basis for discussion with donors about possible new forms of support.

iii. Selection of technology sub-system

Choosing equipment unwisely can have serious consequences. Examples abound of expensive equipment unused due to problems with climate, electricity supply, lack of skilled operators, inability to meet the cost of inputs and maintenance, and so on.[2] It may not be appropriate for health workers in SSA to purchase the models used in developed nation hospitals. Sophisticated models are expensive, and provide a poor service in harsh conditions without skilled personnel to operate and maintain them. Equipment has to be chosen to meet the needs of the health service in which it is to be used.[90-94] It is common however, to find a reluctance amongst health workers to accept anything but the latest 'all-singing, all-dancing' model.

In many countries, equipment has been selected on the basis of the preference of individual health workers, and availability of foreign donor finance. The result is a wide variety of models. As *Gilchrist* discovered, this situation has been exacerbated by donor agency tied-aid policies.[49] The result is the need to operate and maintain many different makes, with spare parts and consumables from many suppliers.

To limit the variety of equipment, standardization is an important element in any rationalization process.[2] Most countries in SSA have not yet implemented such a policy, although there is some evidence of movement in that direction. In Tanzania a project which strengthened laboratories reduced the number of equipment suppliers.[95] Standardization still remains a politically sensitive issue amongst parties holding vested interests, even though the advantages are obvious. Standardization makes it possible for staff to become more familiar with, and better at operating, maintaining, and stocking a smaller range of items. It also establishes a situation whereby suppliers compete for relatively large contracts that have the potential of establishing a long-term market. This gives greater incentive to provide after-sales support at a reasonable cost.

Good selection requires significant investment of time and resources, and access to up-to-date information. Advice is needed from a team of people from various disciplines, including technical staff, architects, planners, procurement officers, administrators, and finance officers, and not simply medical staff. Health service providers must define delivery 'goals' and the functions equipment will serve at different facility levels.[96] Standard lists that use generic specifications rather than brand names should be prepared.[97,98] Then, the *Health Service Supply Council* advises, those responsible for procurement can identify equipment that meets these needs at the most attractive terms.[88]

iv. Procurement sub-system

As *Cooper-Poole* stresses, procurement concerns administrative matters such as obtaining the best possible deal from various sources of supply and organizing the transfer of equipment to the health facility in the importing country.[99]

Contracts with equipment suppliers often concern only hardware supply, leading to the provision of inadequate documentation, poor installation and commissioning, inability to obtain accessories and spare parts, no training, and difficulty in obtaining maintenance support. Tender procedures rarely encourage suppliers to offer these services, and adjudication boards often simply award contracts to the lowest bidder.[3] International donors, who fund a large proportion of equipment imports into least developed countries, have not adequately taken these issues into account.

When adjudicating between offers from suppliers, safety, ease of use, appropriateness to priority health problems, purchase price, life-time cost, and availability of after-sales support need to be taken into account. There is no point in buying an expensive item with capabilities that are hardly ever utilized, or in acquiring one which will be impossible to keep in running order or operate safely and effectively. Although the *EEC* Lomé III Convention (1984) established "economically most advantageous" as the criterion upon which offers should be judged, many health service providers and donor organizations still feel that the best choice is the cheapest option.[50]

It is necessary to organize the logistical activities required to get goods to site, including: raising letters of credit, packaging, freight, insurance, documentation, customs clearance, warehousing, transport, etc.[100] There are many pitfalls in this chain of events which can prevent the safe arrival of equipment. UK medical equipment suppliers estimate that damage or loss of goods in transit can account for as much as 8 per cent of their value.[3]

Many Ministries of Health have little expertise in the procurement of equipment. Supplies officers rarely remember the package of inputs required (accessories, training, maintenance support, etc.). There are numerous examples of hospitals which have purchased inferior products or have neglected commissioning and after-sales services; even of goods being held up at customs or lost en route, for months or years.[2]

v. Preparation for technology use sub-system

Before equipment arrives on site, preparatory work is required to create conditions for it to function reliably and safely. *Steele et al* document common problems when preparing the site including inadequate space, a fluctuating electricity supply, and insufficient water pressure. For example, an x-ray machine can arrive at a facility where the room is too small and power supply capacity too low.[101] Therefore construction work, provision of new service supplies, and hiring of sub-contractors may be required. On arrival, large items or quantities may require the hire of cranes or forklift trucks to unload and position them.[102]

Equipment must be in a reliable and accurate working condition before it is used. Care must be taken to receive, install, commission, and calibrate equipment properly, and train the operators and maintainers to work with it.[101] If these steps are not undertaken or managed well, equipment may never function accurately. Often these activities are omitted from the 'package' at the contract stage. Most suppliers to SSA never install their products explaining that they are either handheld (eg. ophthalmic instruments) or free-standing (eg. operating tables).[3] However, in industrialized developed nations a sales representative would familiarize the client with the correct operation of the equipment, and acceptance testing is an automatic procedure.

vi. Continued operation sub-system

Measures are required to keep equipment in service and retain its reliability, accuracy, and safety throughout its life. *Pfeiff's* "iceberg syndrome" for the life-cycle costs of equipment illustrates that the vast majority of costs are hidden in comparison to the mere purchase price.[103] One element is the continuous supply of adequate consumable inputs (such as x-ray film, ECG recorder paper, gas), accessories, spare parts, and maintenance materials. Problems frequently arise because inadequate funds are budgeted, inadequate quantities are ordered, or reliable local sources cannot be found.

Equipment poses inherent physical risks: instruments are applied to patients; users operate machinery; maintainers dismantle equipment; technology deteriorates over time; it consumes electricity, gas, and hazardous chemicals; accidents happen; and hygiene is crucial.[104] Dangers arise when equipment does not perform well (inaccurate anaesthetic machines), is mis-used (adult suction pumps applied to infants), and is in poor condition (electrical faults from fraying leads). Regular supervision and monitoring is required to achieve safe working practices: equipment operated by well trained staff, implementation of safety procedures, and regular planned preventive maintenance (PPM).

If the service the equipment helps to provide is to be continuous (ie. blood testing at district level), suitable mechanisms are needed to dispose of and replace equipment automatically at the end of its life. Technical judgement is required to assess when equipment no longer meets minimum standards of safety and effectiveness, and to replace it before incurring excessive expenditure on maintenance (*Mitchell et al*).[90] Then equipment needs to be disposed of promptly and safely. However, many observers cite facilities with 'graveyards' of old stock which block basement corridors, store rooms, and grounds.[2]

vii. Maintenance and repair sub-system

When equipment breaks down, the lives of patients are put at risk. Unreliable or inaccurate equipment is often worse than none at all. For example, autoclaves must be hot enough to sterilize and x-ray machines must produce diagnostic quality radiographs. Users and patients are also at risk from exposure to radiation or electric shock. Effective and safe equipment must be available to health service providers at as low a cost as possible. Thus it is important to establish an effective maintenance service.[105-108]

Often health equipment maintenance in SSA is management by crisis. As *Bracale* found, problems are not planned for and when they arise makeshift solutions have to be found.[109] Little financial provision is made for maintenance. If a piece of equipment is working, the tendency is to leave it alone; virtually no PPM is undertaken. New items are ordered when minor repairs could make existing equipment functional. A number of reports have documented the weaknesses of many of the maintenance services.[2,24]

Health services often have to choose between paying large bills to a foreign contractor, accepting that equipment will be frequently out of order, and not purchasing the item at all.

For example, when undertaking a study in Nigeria *McKie* found equipment which had been awaiting repair for months or years.[110] Even simple equipment, whose maintenance and repair requires only basic craft skills and simple materials, is unusable.

The question for countries is who should maintain the different kinds of healthcare technology? In contrast to industrialized countries, health services in many developing countries can rely on neither in-house units nor private companies for maintenance. The inherent knowledge that manufacturers have about their own products is invaluable, however the quality and range of service available from private sector firms varies: simply sales outlets; offering technical support but without the requisite skills or resources; offering a good service but expensive or based far away.[3,107,108] Health service providers will have to make substantial investments to establish effective maintenance services of their own. The relative roles of the public and private sectors varies with the technological sophistication of the equipment. As *Winger* and *Styles* recognize, most countries will require a balance of in-house and private sector maintenance support.[111,112]

The *WHO* advised that any national central equipment management body should be headed by a technical person to co-ordinate management of maintenance through a network of maintenance workshops.[2] But the establishment of such an 'in-house' service requires a substantial investment of management effort. It will not be enough to train technicians. They need adequately equipped workshops and an organized service with reasonable pay levels and a well defined career structure.[113] Good management practice is required for running the workshops, prioritizing jobs, implementing PPM, keeping records, supervising staff and quality of work, as well as planning and budgeting, etc.[113,114] Contracts must be monitored to review quality and price. The maintenance service must be adequately funded, for as *Barraclough & Cronin* state "there is one message that we cannot reiterate sufficiently, it is that **maintenance is expensive** – unless adequate funds are actually available, the repair of equipment will not take place." [115,116]

viii. Personnel sub-system

Health services need adequate numbers of different cadres with sufficient skills to perform their allotted roles in the first seven sub-systems: users, maintainers, safety inspectors, purchasing officers, stores personnel, tender adjudicators, administrators, managers, etc. Each discipline requires a broad spectrum of personnel, for example the maintenance system needs artisans, technicians, engineers, and technical managers in different specialities (electrics, mechanics, plumbing, refrigeration, electronics, etc).[84] The staff employed need basic qualifications for their profession, but also specific training/orientation for the role they will play with equipment.

A *WHO International Meeting* agreed that many developing country health services are short of a wide range of different cadres, and either rely on expatriates or do without these skills.[84] Even if the necessary skills are available within the country, it may not be possible to retain them in the public sector due to prevailing working conditions (poor salaries and career structures, lack of posts, etc). Most countries in SSA are only just beginning to address these issues, and have only small numbers of technical cadres and fledgling equipment management units.

ix. Training sub-system

An on-going training programme for different cadres is a necessary part of a healthcare technology development plan. Skills are required in: selection, writing and adjudication of tenders, procurement, operation, safety, maintenance, and management. In SSA, where it is necessary to establish many of the functions for the first time, the training programme takes on an even greater importance.[84] It is argued that the focus must be on the practical skills, including management, which are necessary for keeping the bulk of equipment functioning. Theoretical courses must be linked to hands-on experience in a working health environment. For maintenance staff, it is common to find underfunded services where morale is low and technicians have undergone a process of de-skilling.[110,117] Thus it is not enough to send cadres away to acquire technical skills.

The training programme needs to combine inputs from a number of different institutions: formal training courses abroad, short updating workshops run by manufacturers, in-country courses, and long-term technical assistance from donor agencies. The *Commonwealth Secretariat* found that several initiatives in SSA have foundered on: lack of regular throughput of sufficient numbers of students; shortage of training scholarships; poor entry qualifications of applicants; and conflicts over the most appropriate level of training and qualification to offer.[118] A mix of strategies must make the most of local basic training, on-the-job training, scholarships for courses that do exist, and bonding of students trained whilst in service.

Furthermore, a programme of continuing education is needed for the equipment sector. This enables users and technicians to upgrade their skills and keep up with developments in the field – especially important in countries with a relatively small healthcare technical service and a high turnover of personnel. It is essential to have a system of on-going training for equipment operators, since it is generally agreed that the majority of maintenance workload is due to operator error and mis-use. Most ministries of health have, as yet, not developed or implemented such comprehensive in-service training programmes.

x. Technology assessment, research, and product development sub-system

To make the best use of an evolving technology, capacities in technology assessment, research, and product development are required which will inform the other component sub-systems. The health sector uses a wide range of equipment, and models are superseded within a few years. It requires considerable effort to keep up-to-date information on all available products and provide it to decision-makers. Large organizations, such as *ECRI* in the US and *The Department of Health* in the UK, collect and analyze information, but are situated in the developed world.[119,120] There exists no comprehensive source of information to which countries of SSA can refer besides subscribing to databases which are oriented to their country of origin (eg. UK, US). Thus countries of SSA need strategies for gaining access to as much relevant information as possible without incurring great costs.

The healthcare technology industry is evolving rapidly. In 1994, *Nobel* reported 750,000 medical devices (produced by 10,000 manufacturers) on the world market, and he estimated that by 2000 this figure would double.[28] *Banta* observes an increasing number of technology assessment studies.[121,122] However, only a small number of them concerned the use of equipment in developing countries.[123-125] This leaves many health services utilizing costly and potentially risky technologies without much evaluation.[126]

Investment in research brings about changes in the design of healthcare technology. Virtually no such expenditure is being made in SSA. For example, the WHO identified the need to develop laboratory equipment designed for conditions found in developing countries (*Mitchell*).[90] International firms however, are reported to be unwilling to undertake the necessary product development – not having an economic incentive to develop equipment appropriate to the needs of poor countries (*Hartley & Hutton*).[45]

The analysis presented here suggests that research on the more effective use of healthcare technology in developing countries might include: the development of appropriate equipment; assessment of existing technologies; and research into alternative ways of structuring the relationship between suppliers of equipment and the health sector (*Bloom & Temple-Bird*).[3]

xi. Local production sub-system

Countries may wish to start to reduce dependence on importing equipment from abroad, and the final sub-system covers the capability for local production of parts or entire units. In the 'Programme for the industrial development decade for Africa' prepared jointly by the *Organization of African Unity* and several *UN* agencies in 1982, the possibility of manufacturing healthcare technology within SSA was put forward.[127]

A number of products could be manufactured in countries with relatively weak industrial sectors, including basic consumables, furniture, prosthetics and simple laboratory equipment. In addition, parts could be produced, or there can be assembly of entire units from imported components. In North Africa, for example, some countries produce wheelchairs, trolleys, beds, prosthetic limbs, non-chemical consumables, and medical gases, while more industrialized countries (such as Egypt) manufacture larger items: furniture, kitchen and laundry equipment, autoclaves, etc.[128] Manufacture of high technology items is limited to a country like South Africa, where healthcare technology manufacturers were forced to develop their own products whilst isolated from international trade.

4.3.2 Four 'Players' who Provide the Different Components of the Package

To assess possible strategies for improving the capacity to use healthcare technology effectively, the modelling framework has broken the package system of necessary inputs into 11 component parts. The next step is to identify the various sub-system actors with a role in providing the various elements of the service (see Figure 4.1).

The 11 components of the healthcare technology package are provided by a number of institutions operating nationally, within the region (SSA), from exporting countries, or internationally. They include public sector institutions, private companies, non-profit organizations, and international organizations. The Ministry of Health may be responsible for a number of components. However, some functions such as maintenance, may be provided by a whole variety of institutions. It is important to assess the resources available and identify the constraints. A well managed healthcare technology service can then choose which of these resources best provide each component of the healthcare technology package. Decision-makers need a clear understanding of the existing situation. Such information is invariably unavailable.

In any country these actors will be moulded by and reflect the national background context (Section 4.3.3). My preliminary analysis suggested the actors could be seen as four sub-systems covering the following broad categories of institutions:-

a. Health service providers

The management and use of equipment is the responsibility of health facilities, and these belong to the public, mission, mining/industrial, and private sectors. Health services are provided by co-ordinating bodies such as the Ministry of Health, other ministries with a major involvement in health services (such as Local Government), any Church Health Association, and often the defence and industrial sectors.

Within these facilities and organizations are a vast range of people whose daily decisions affect the life of equipment. They work in departments such as finance, supplies, personnel, training, planning, external aid, administration, clinical services, paramedical services, and technical services. The situation can be complex; staff cover many of the sub-systems of the HTP, but still leave crucial equipment activities unaddressed.

b. Public sector maintenance organizations

Most countries have several public sector maintenance organizations that provide services to the health sector. The Ministry of Works often looks after plant, the Ministry of Supplies cares for furniture, the Ministry of Health is responsible for medical equipment, with other ministries taking responsibility for water, electricity and gas supplies. The co-ordination of so many organizations is complex; perhaps none provide a particularly good service, but there may be untapped technical resources for the healthcare technology sector. The process of privatizing public sector maintenance organizations will also impact on healthcare technology.

c. Private sector institutions (both national and international)

Many institutions in the private sector, both locally and abroad, have a role in the life-cycle of equipment. There are the international equipment manufacturers, their regional subsidiaries, local agents and distributors, as well as local manufacturers and general wholesalers. Also, there are independent maintenance contractors, training companies, and consultants. Others include: overseas training institutions, licensing and standards authorities, database gatherers, research bodies, overseas health service institutions, international organizations and authorities, procurement agents, freight forwarders, manufacturers of consumable supplies, development banks, etc. The size and strength of a country's industrial sector will dictate how much technological support it can offer.

d. National support environment (comprising national and international actors)

Within a country, a number of institutions (national and international) have functions relevant to healthcare technology and make up the environment in which such technology will have to survive. Various ministries may have procedures and regulations which create constraints to the rationalization of the sector, for example the Ministry of Trade and Industry has influence over standardization initiatives, Works over design of health facilities, Finance over funding for long-term development plans, and the Public Service Commission over establishment of posts for the healthcare technical service. In addition, there will be the national training capacity, regulations of the Tender Board, the role of professional associations, and the efficacy of bodies such as the Electricity Supply Commission.

Also, external support agencies operate in countries and provide (ever-changing) material support to health service providers and their programmes. Within this environment, it is important to discover whether there is sufficient technical and management expertise to enable healthcare technology to be imported effectively, and whether policies and practices of agencies conflict with the goal of rationalizing the healthcare technology sector. Then new models that would encourage longer-term planning of the equipment service can be considered.

4.3.3 Areas of Study which Provide the National Background Context

Knowing the background context of the country in which the equipment is trying to function is important. Preliminary analysis suggested four context sub-systems providing data on the national:

* health system
* education system
* economic status
* industrial strength,

to provide an idea of the stage of development. Then, any initiatives undertaken to strengthen capacity to import and use healthcare technology will be relevant to the particular country concerned.

4.4 USEFULNESS OF SUPPORTING LITERATURE

In 1988, some technology transfer literature (such as *Stewart*) provided an impetus for the development of my HTP system by arguing for "unpackaging" technology, in order to analyze the components required if the technology is to be successfully adopted.[82] I propose that the import of healthcare equipment is an example of the direct transfer of technology. Experience in the health sector has demonstrated the need to complement the purchase of equipment with a number of other inputs. For my research, I wished to review subsequent technology transfer literature to see if it discussed the success of transferring technology to developing countries once unpackaging had been considered. The literature studied was both general, and specific to the health sector.

The general technology transfer literature covers any technology transferred to any developing country. The vast majority of this literature focuses on so-called 'productive processes' and the appropriate role of foreign investment in development.[129] As the focus was on manufacturing, 'success' of transfer was judged in terms of whether a market was found for the products manufactured and the level of state intervention.[130,131] For example *Enos & Park* discuss the 'success' of petrochemicals, iron, steel, and textiles in Korea, as opposed to 'less successful' medium-sized diesel engines for which the forecast of demand had been in excess of the eventual sales and thus profitability.[132] *Lall* talks of the competitiveness of transferred steel, cement, and iron production in India, and he and *Niosi & Rivard* use the definition of 'technological capability' as the ability of an exporting firm to develop a technology to such a state that it is able to be transferred.[133,134] This illustrates the problem of terminology in the literature as, in contrast, *Fransman & King* define 'technological capability' in terms of human skills, and how engineering staff should be employed in the recipient manufacturing sector.[135]

Other literature concentrated on agriculture and the transfer of technologies to process foods such as irrigation, threshing, and sugar production. The focus was on ways to influence policies so that production can be "owned nationally" and on finding 'appropriate' technologies.[136,137] Much of the general technology transfer literature takes a rather abstract approach, for example *Fransman & King*.[135] Others go down the route of measuring success through mathematical equations, for example *Besley & Case* develop mathematical models for the adoption rate of technology (ie. the use of tractors by farmers instead of the use of cattle and ploughs).[138] *Page* develops equations to reflect technical efficiency and economic performance, and *Enos & Park* use equations to illustrate the "static economies of scale" when considering the reduction in unit manufacturing costs.[139,132]

For my perspective on healthcare technology, this literature was disappointing. As an engineer, I was looking for some discussion on how the machinery (ie. the manufacturing plant) had survived after the manufacturing process had been transferred. To my surprise, the literature does not refer to how well the recipient coped with the actual machines on the production line, nor valued that as a measure of success. I was also hoping for reference to the required components of the 'package'. Some of the literature did touch upon some of the sub-systems I had identified as essential parts of the package. However they are touched on briefly with no suggestions for solutions. For example, when discussing the transfer of manufacturing technologies to Kenya and Tanzania, *James* does stress the importance of considering installation, maintenance, and running costs when selecting the technology.[140] *Enos & Park* talk of the importance of properly selecting, procuring, installing, and learning to use technology.[132] *Lall* mentions the need for maintenance, tools, spare parts, workshops, and a debugging period after installation.[133] *Pickett* discusses the different types of labour required for different machines.[141] The need for a 'holistic' approach was mentioned in a line or two.

In fact, later, *Cusumano & Elenkov* studied the deficiencies of international technology transfer literature and concluded that it "has mostly concerned itself with the terms of the transfers, neglecting the more important consideration that the subsequent functioning of the technology, which determines its value to the recipient, depends crucially on the cultivation of appropriate technological capabilities by the latter".[142] But they also studied technology strategy and management literature and felt that international technology transfer "requires a strategic and managerial perspective in order to create a coherent set of 'firm'-level policies, organizational initiatives, and organizational capabilities". Some sources of literature did recognize the importance of the role of what I term the sub-system actors, and these sources are reviewed in Chapters 6 – 10. However *Mytelka* warned, when reviewing the unfulfilled promise of African industrialization over the previous quarter of a century, that "excessive reliance on foreign aid donors, technology suppliers, and investors for product and process choice and enterprise management limited the building of indigenous technological capabilities and led to numerous lost opportunities for learning".[143]

It was difficult to find literature specific to the health sector in the technology transfer literature, and most sources fell under the 'technology assessment' field. Immediately there was a problem with terminology, since the word 'technology' is used to cover such a broad field. Many technologies are 'medical supplies' such as vaccines, oral rehydration solution, contraceptives, etc (*Free*), or 'systems' such as drug labelling (*Gelband et al*) and screening for HIV (*Rosenbrock*).[144-146] Other sources (*Burney* and *Homma & Knouss*) discuss transferring the ability to manufacture, but in this case the technology is a vaccine.[147,148] Again, success is measured as the take-up of the medical supplies or the system, and discussion of the ability to cope with any hardware involved in the process (eg. labeller, laboratory equipment, production line) is limited to a sentence or two. Some sources do discuss the transfer of specific types of medical equipment, such as nuclear medicine (*Kouris & Abdel-Dayem*) and imaging technologies (*Hu*).[149-151] This literature reiterates the problems of transfer but does not offer solutions.

Some of this literature did touch upon the sub-systems I had identified as essential parts of the package, such as *Whelpton* who also stressed the importance of "complete equipment management".[152] The best and fullest discussion of the package was by *Prage*, in a discussion of an associated field facing the same problems as healthcare technology – that of scientific instruments in the universities of developing countries.[153] Thus there was limited evidence of literature taking a technological systems approach. Some of the technology assessment literature, however, did recognize the importance of the role of the four categories of players. For example, *Serpa-Flórez* discusses the need for and ways in which "providers, users, health ministry employees, and industry all share responsibility for proper planning and careful implementation" in order for medical technology to contribute to improving the health status of people in developing countries.[154]

Overall, I found no detailed study of the kind I proposed. My proposed approach, to focus on the healthcare technology system in detail, studying how the whole system could be better organized, was original.

4.5 CONCLUSION

Many problems currently experienced by developing countries with healthcare equipment have arisen due to the lack of ability to manage technology as a complex whole. Only recently have countries in SSA begun to establish fledgling healthcare technology management units. There are no internationally agreed guidelines on how such units should function. My interest in the sustainability of the healthcare technology sector in developing countries led me to develop a modelling framework for the formulation of strategies for improving healthcare technology management, using systems analysis.[78-81] Some of the technology transfer literature of the time proposed that the successful adoption of any new technology involves considerably more than the purchase of a piece of equipment; it requires a package of inputs.[82] When some of the necessary elements are absent or inadequate, the consequence is costly but ineffective use of imported technology.

This Chapter reviews the modelling framework that I developed. I propose that the effective importation of technology into the healthcare environment, will be aided by studying the healthcare technology package system: first studying 11 components of the package, secondly by studying four players with a role in delivering these components, and thirdly considering four national background context areas. The structure of the modelling framework underwent some minor refinement over the course of its use during the PhD research, with its basic contents remaining the same but the form of labelling changing. Thus this Chapter discusses 19 proposed sub-systems of the package.

I reviewed various technology transfer and technology assessment literature in the hope of discovering successful technology transfer to developing countries, the efficacy of unpackaging, and a discussion of a technological systems approach. However, I found it did not consider what had happened to the **hardware** that was transferred (ie. the production line) rather than the products produced. Nevertheless, some of the literature pointed towards the importance of organizational capabilities, the role of suppliers, and the national support environment. These topics and their supporting literature will be covered in subsequent Chapters of my Thesis, in order to assist the discussion of the issues discovered during the country case studies. The literature did not, however, point to the kind of holistic approach I felt was key.

I propose that by studying these sub-systems I am taking a *Technological Systems* approach, as defined by *Hughes*, since I am analyzing a system containing messy, complex, problem-solving components.[83] The system I am analyzing is also a complex system since it is made up of many institutions (actors) with a role to play (*Buckley*).[80] By taking this perspective, I suggest that it will be possible to dissect and consider the healthcare technology sector, and to identify the current good practices and constraints. With this information, it will then be possible to consider different combinations of initiatives that will facilitate the best use of imported technology. Thus having hypothesised and developed a modelling framework to analyze the healthcare technology sector, it was necessary to apply it to real country situations and this formed my PhD field work, whose case study methodology was described in Chapter 3. Chapter 5 begins to detail the results of what I learnt from the case studies, by discussing the problems found with the healthcare technology sectors of Zambia, Botswana, and Namibia over the last decade.

CHAPTER FIVE: STATE OF THE EQUIPMENT SECTOR FOUND IN THREE COUNTRY CASE STUDIES

In Chapter 4, I presented the holistic HTP system for analyzing the healthcare technology sector. Having hypothesised this modelling framework, it was necessary to apply it to real country situations to discover if it was a useful heuristic tool. Chapter 3 described the application methods in three different countries at three different times. These case studies enabled me to continue my first theoretical perspective and take a *Technological Systems* approach when studying their healthcare technology sectors. Taking this holistic approach allows investigation of my second research question:-

Q2 What are the key constraints to sustainability and what common problems persist?

This Chapter starts by discussing the state of the healthcare technology sectors of Zambia in 1990, Botswana in 1992, and Namibia in 1997. Section 5.1 begins the context sub-systems analysis by presenting background statistics on the countries, as well as data on the condition of the large samples of equipment studied, indicating how well healthcare technology was managed. Section 5.2 summarizes the findings for the 11 component sub-systems and sub-system actors within the HTP system, indicating how well different management activities were performed. Thus this Chapter maps the healthcare technology systems in three case study countries using a *Technological Systems* approach. My analysis allows me to draw out five fundamental overarching themes influencing the sustainability of the HTP system (Section 5.3), which are studied in detail in Chapters 6 – 10.

Table 5.1 provides an overview of the differences between the countries, by comparing various features applicable at the time of the visits, such as terrain, economy, population, etc.[55,69,71,73,155-160] All three countries are large – Zambia being approximately equivalent to Sweden and Norway combined, Botswana to Spain and Portugal combined, Namibia to France and Germany combined – with the associated problems of vast distances in the health delivery system. They all have problems of high temperatures, with Botswana and Namibia suffering from the extremes associated with desert terrain. They all suffer from dust that penetrates equipment, and Zambia's more consistent rainy seasons means humidity affects equipment. Zambia had the highest population and hence the greatest number of health facilities, and numbers and spread of equipment around the country. Botswana's and Namibia's small populations mean greater distances between facilities, and only small pools of technically skilled people. All had large sections of their populations in poverty, and poor health statistics typical for least developed countries. None of them had large industrial or manufacturing sectors. At the time of the country studies, Zambia was in severe economic crisis and could not trade with its neighbours, Botswana was rare for SSA with its accounts in the 'black' and relatively close links to its industrial neighbour South

TABLE 5.1: A summary and comparison of features of the three countries studied[55, 69, 71, 73, 155-160]

Feature	Zambia, 1990	Botswana,1992	Namibia, 1997
Size, sq km Population % in urban areas	753,000 7.37 million 53%	600,400 1.3 million 33%	825,000 1.58 million 50%
Main population-distribution	40% along 3 main rail routes from Lusaka.	83% along NE-S rail line through the 2 major cities.	66% in N where water is, 10% in S
Terrain	Tropical grass/wood-land, scrub, savanna	Semi-arid (delta), arid, desert.	Semi-arid (coast) to hyper-arid (deserts).
Climate	Hot, humid, with a rainy season.	Hot, very low rainfall.	Extreme hot & cold, very low rainfall.
Height above sea level	Mostly on 1000-2000m plateau.	Mostly on 500-1000m plateau.	Mostly 1000-2000m plateau, except coast
Location	Landlocked, in Tropic of Capricorn.	Landlocked, in Tropic of Capricorn & south.	Has a Sth Atlantic coastline, in Tropic of Capricorn & Sth.
Main export income	Copper, cobalt	Diamonds, gems, soda lime, minerals, beef.	Diamonds, gems, uranium, industrial minerals, fisheries.
State of earnings	Falling since '70s with copper prices.	Rapid growth since '66.	Great pressure on resources to correct inherited apartheid inequalities.
GDP[1] per head Pop. below absolute poverty % of GDP on health	400 US \$ >25%[4] 3.2%	3640 US \$[2] 50% 6%	2059 US \$[3] 60% 15%
Infant mortality rate Under-5 mortality rate Maternal mortality rate	107 per 1000 190 per 1000 150 per 100,000 live births	35 per 1000 48 per 1000 250 per 100,000 live births	57 per 1000 83 per 1000 225 per 100,000 live births
Year of Independence	1964	1966	1990
No. of hospitals No. of health centres No. of health posts Increase in hospital beds	82 900[6] [6] Doubled since '64	31 170 308 Five-fold since '74	43 (& 33[5]) 225 900 Massive expansion mid-60s - early 90s.
Last major investment in health facilities	Late 60s-early 70s	In '80s, upgrading plans for '90s	In '80s, renovation plans for '90s
Tertiary education enrolment as % of relevant age group	2%	3%	7%
% of labour force in industry	8%	20%	15%

1. Gross domestic product.
2. However, the richest 20%'s share of total income is 66.4%, whereas the poorest quintiles's share is 1.4%.
3. Most skewed in the world – the richest 1% consume as much as the poorest 50%.
4. This figure only applies to the urban population, data for the rural population was unavailable.
5. Namibia calls 33 of these facilities 'health centres', but with 10 beds they may equal other countries' definition of rural/primary hospitals.
6. Zambia does not split its classifications between 'health centre' and 'health post'.

Africa, and the new government in recently-independent Namibia had inherited extreme inequalities from the previous apartheid regime but retained strong trade links with S.Africa.

5.1 BACKGROUND ON THE COUNTRIES AND THE STATE OF THEIR EQUIPMENT

5.1.1 Zambia in 1990

Zambia is a large country of approximately 753,000 sq.km, with an estimated population of 7.37 million, a high percentage of which (53%) live in urban areas. It fell within the World Bank's definition of a low-income country and was facing an acute economic crisis. Its 82 hospitals and 900 health centres were not equally distributed but were concentrated in the provinces along the three main rail routes from the capital, Lusaka, supported by a flying doctor service.[159] The number of facilities had increased markedly since independence (1964) with hospitals and inpatient beds doubling, and a large expansion in rural and urban health centres.[160]

Most of Zambia's hospitals were built before the fall in earnings from copper, and many were constructed using inappropriate European designs. As earnings fell, insufficient resources were allocated to sustain hospitals, either through maintenance or capital replacement. By 1990, the Ministry of Health was experiencing increasing difficulties with healthcare technology, causing serious disruptions to hospital services and significantly undermining standards of care. Hospitals were trying to function with items of equipment acquired in the late 1960s and early 1970s (long past the end of their natural lives), that had suffered considerable neglect. By 1990, the severity of the problem had been recognized by the government and donor community. Dealing with it had become a priority strategy in the Government of Zambia's *Fourth National Development Plan.*[161]

During the country study, I employed physical surveys of equipment as one methodology (Section 3.3). Visits were made to government and mine facilities, and mission health service authorities. One type of sample was the 1500 items of equipment and plant examined at six government hospitals.[69] As an example, Table 5.2 summarizes the condition of the 753 items of medical equipment inspected. The major findings for all types of technology were that:-

* Much of the medical equipment was old (many being museum pieces); of the items examined, 30% was over 20 years old and almost 65% was over 10 years old.
* Of the medical equipment examined only 36% was found to be working satisfactorily. Of the remainder, 41% was broken, 19% was working at fault, and 4% could not be used due to a lack of consumables or skilled operators.

TABLE 5.2: Sample of equipment at selected Zambian hospitals – 1990

Department/ Equipment type	Total pieces of equipment examined	% Working					% Broken				% Age			
		OK[1]	But cannot use[2]	At fault[3]			<5 years	5-9 years	10-20 years	>20 years	<5 years	5-9 years	10-20 years	>20 years
				<1 year	1-5 years	>5 years								
Operating Theatres including Theatre Sterile Supply Units	153	20%	3%	–	20%	7%	26%	13%	9%	2%	9%	8%	48%	35%
				Total 27%			Total 50%							
Intensive Care Unit (ICU)	91	19%	4%	2%	–	–	59%	15%	–	–	11%	41%	42%	6%
				Total 2%			Total 75%							
Laboratory	254	43%	7%	3%	11%	1%	26%	7%	3%	–	9%	21%	47%	23%
				Total 14%			Total 36%							
General Imaging Units	131	49%	2%	2%	17%	4%	7%	11%	8%	1%	7%	8%	65%	20%
				Total 23%			Total 26%							
Premature Baby Unit/Labour Ward/Paediatric ICU	89	26%	2%	3%	19%	9%	28%	8%	5%	–	5%	8%	45%	22%
				Total 31%			Total 41%							
Dental Unit	18	44%	6%	–	6%	–	33%	6%	6%	–	17%	11%	–	72%
				Total 6%			Total 44%							
Clinics – various	17	53%	–	12%	18%	–	18%	–	–	–	18%	12%	35%	35%
				Total 29%			Total 18%							

1. Performing as intended and being used.
2. Performing as intended, but unable to use because necessary inputs were unavailable, such as consumables, relevant skills, etc.
3. Not performing as intended or unsafe, but still in use because staff were unaware of the problems or desperately required some form of assistance from the equipment.

* Over 60% of plant was 20 years old or more, and its poor status was affecting the ability of the hospital to function. For example, at least 80% of steam autoclaves needed replacing.
* Of the 120 items of kitchen equipment examined only 28% was found to be working satisfactorily. 29% was broken and 43% was working at fault.
* The hospital buildings were 18-35 years old on average with some buildings as much as 60 years old. Whilst not being a problem in itself, the low level of maintenance over a long period meant that buildings and services were in a very poor state of repair.

The resultant effects on health service delivery were serious. Building fabric was in disrepair: roofs were leaking, ceilings losing plaster, doors off their hinges, and windows broken. The worst implications arose in theatres or Central Sterile Supplies Departments (CSSD) where the sterile environment was compromised. There was strong visual evidence of rats chewing through wires and posing other more obvious drawbacks. There were low levels of lighting, faulty socket outlets, broken air-conditioning plant, made worse by European 'submarine' designs which relied totally on creating an artificial environment. Every circuit might be compromised due to missing circuit breakers that had a blackmarket value of 10-days salary for hospital workers. There were major problems with water supplies, and one central referral hospital had been without running water for 10 years. With inappropriate multi-storey hospital designs and broken lifts, in the worst cases patients were carried up stairs by staff whilst corpses were carried down.

The age and condition of plant meant that hospitals were grinding to a halt; many had to function without boilers to provide hot water or steam, without assisted ventilation, with failing mortuary freezers, and with limited laundry and kitchen services. One hospital had one toilet working for wards holding 400 patients.

The poor state of medical equipment meant there were limitations to many services: no blood gas analysis; little neonatal resuscitation; teeth extracted instead of filled; and casualty departments without the most basic, let alone life-saving, equipment. Basic health delivery 'tools' were affected:

- without laboratory tests, diagnosis could not be made;
- without autoclaves, instruments could not be sterilized;
- without x-rays, patient investigations could not be made.

Such conditions over many years left staff demoralized, frustrated, and feeling hopeless. Interviewees reported many instances of life-saving attempts frustrated by the lack of simple items, ie. without grasping forceps a baby choked to death on an obstruction. It was remarkable that so much good work continued and pockets of optimism were still found.

For public sector medical equipment maintenance, there was one central national workshop in Lusaka with eight technicians of varied and uneven capabilities to support and undertake maintenance for 43 hospitals across the country by outreach. Six of Zambia's nine provinces were covered by one technician or trainee only; the rest had none. For hospital buildings and plant, the government had recently disbanded the Mechanical Services Department of the Ministry of Works and Supply who formerly maintained all government buildings. The MOH was trying to absorb the 70 technicians, of differing disciplines and competence, and redistribute them around the country for each province to have a multi-disciplinary team for all maintenance in health facilities. During the changeover, the level of maintenance successfully undertaken was affected. The largest referral hospital of over 1500 beds (University Teaching Hospital – UTH – Lusaka) had parastatal status. By contrast, it had set up its own medical equipment maintenance department with eight technicians, and the main hospital workshops employed a multi-disciplinary team for all other equipment areas. Still work was limited by financial constraints.

Another sample taken was the equipment in mine hospitals. By comparison with government facilities, the standard of inspected items was good. Although much was old, it was well maintained. Laboratory, theatre, kitchen, and dental staff reported that they were well equipped, repairs were done quickly and effectively, and there were usually "no problems" getting spares and consumables. Regularly scheduled preventive maintenance was carried out on all equipment. The Zambia Consolidated Copper Mines (ZCCM) were having a greater degree of success with equipment of similar age and type than those in government hospitals under the same national climate and conditions. This led me to pursue the issue of institutional differences in the sustainability of healthcare technology, and Chapter 6 investigates in what way institutional organization issues contribute to the differences found.

Zambia's private sector was small with health equipment being no exception. In the past, quite a range of health equipment had been maintained by private maintenance contractors which were either subsidiaries of manufacturers or their appointed agents. However due to the economic and political crisis, by 1990 only a handful of these companies were still active in the sale or maintenance of healthcare technology. Due to MOH financial constraints little use was made of them.

In the 20 years since UTH and Ndola Central Hospital had been completed, there had been only a few initiatives by donors to equip government hospitals. In these instances, the MOH had been vulnerable to outside pressure to accept unsuitable equipment (Chapter 10). In addition, there had been some external support agency backing for the maintenance services. 30 of Zambia's hospitals were church-run, and much of their equipment was donated prohibiting attempts at standardization.

5.1.2 Botswana in 1992

Botswana is a large country of approximately 600,400 sq.km with an estimated population of only 1.3 million, approximately one third of whom live in urban centres. Much of the country is arid and sparsely populated; in 1981, 83% of the entire population lived in a strip of land running from south to north-east along the railway line. Botswana had enjoyed rapid economic growth in the 25 years since independence (1966), largely due to major diamond deposits and the growth in export beef and soda lime industries. In 1992, *Harvey* recorded that Botswana had been transformed from one of the poorest countries in the world during the 1960s to one of the richest in Sub-Saharan Africa.[162]

The government's *7th National Development Plan* recorded a substantial health sector expansion since the early 1970s; between 1974 and 1990 health posts increased from 23 to 308, clinics from 50 to 170, and primary hospital beds increased five-fold.[163] There was little investment however in district and referral hospitals until the late 1980s, but the completion of the Nyangabgwe Referral Hospital in Francistown and the planned upgrading of the Princess Marina Referral Hospital in the capital Gaborone, represented a qualitative change in the sophistication of services and numbers of technically complex pieces of equipment.

During the country case study, physical surveys of equipment were taken at a range of facilities; 913 items of equipment were examined at government, mission, and mine hospitals (Section 3.3).[71] One sample was the 609 items of medical equipment examined at four government district hospitals which were maintained by MOH's Medical Equipment and Maintenance Services (MEMS). Table 5.3 summarizes their condition; the major findings were:

* On the basis of staff reports and the appearance of equipment, it was estimated that most was between 8 and 18 years old. Only 45 items (7.4%) were identified as having been brought into use during the previous five years.
* 76 items of equipment (12.5%) were found unissued in stores departments, 79% of which were new and functioning perfectly but had never been distributed.
* Only 57.5% of equipment available was functioning satisfactorily and in use.
* 16% of equipment was broken, 24% working at fault, and 2.5% could not be used because staff did not know how to operate it, or there were insufficient or incompatible accessories available.

TABLE 5.3: Sample of equipment at selected Botswanan hospitals maintained by MEMS – 1992					
Department/ Equipment Type	**Total pieces of equipment examined**	**% Working**			**% Broken**
		OK[1]	**But cannot use[2]**	**At fault[3]**	
Operating Theatres	107	60%	5%	19%	16%
CSSD	9	44%	–	56%	–
Minor Surgery	26	77%	4%	8%	11%
Laboratory	178	62%	5%	15%	18%
X-ray Departments	33	70%	–	30%	–
Maternity/Labour	111	59%	3%	18%	20%
Dental Units	65	63%	3%	22%	12%
Stores	76	–	79%	–	21%
Incinerators	4	25%	–	25%	50%

1. Performing as intended and being used.
2. Performing as intended, but unable to use because necessary inputs were unavailable, such as consumables, relevant skills, etc.
3. Not performing as intended or unsafe, but still in use because staff were unaware of the problems or desperately required some form of assistance from the equipment.

The effect was an overall shortage of equipment required to carry out basic health service functions. Hospitals did not have certain items (defibrillators, monitors, resuscitation units, full instruments sets for surgical procedures, etc.), and there was a shortage even of small simple items (gas gauges, doppler units, diagnostic sets, etc.). Many items were not working effectively such as centrifuges that only ran at low speed, and dental chairs whose position could not be altered. More worryingly, items were working at fault with users not always aware of sub-standard performance, such as photometers giving inconsistent results, and suction pumps used on too high a setting for infants.

Table 5.4 summarizes the condition of 98 items of plant examined at the same four government hospitals, which were being maintained by the Ministry of Works' Department of Electrical and Mechanical Services (DEMS). The major findings show that:

* Most plant was as old as the buildings having been installed during construction, thus ranged from 10 to 35 years old.
* Only 44% of equipment was functioning satisfactorily and in use.
* 28% of equipment was broken, and 25% was working at fault or ineffectively (varying considerably with the type of plant).
* 3% of equipment could not be used due to long delays with installation.

TABLE 5.4: Sample of plant at selected Botswanan hospitals maintained by DEMS – 1992					
Department/ Equipment Type	**Total pieces of equipment examined**	**% Working**			**% Broken**
		OK[1]	**But cannot use**[2]	**At fault**[3]	
Air Conditioners	18	44.5%	–	33.5%	22%
Extractor Fans	3	33.5%	–	–	66.5%
Mortuary Units	6	100%	–	–	–
Refrigerators	29	69%	3.5%	17%	10.5%
Hot Water Geysers	7	14%	14%	14%	58%
Generators	4	–	–	100%	–
Laundry equipment	15	20%	–	13.5%	66.5%
Kitchen equipment	16	69%	6%	25%	–

1. Performing as intended and being used.
2. Performing as intended, but unable to use because necessary inputs were unavailable, such as consumables, relevant skills, etc.
3. Not performing as intended or unsafe, but still in use because staff were unaware of the problems or desperately required some form of assistance from the equipment.

The effect on services was a shortage of the items necessary for controlling the hospital environment – there were problems with keeping rooms cool, obtaining hot water, and providing ventilation. Hospitals often had non-functioning laundry equipment and inadequate kitchen facilities. There were severe problems with obtaining replacement or repair for plant.

Being the most economically viable country in SSA, external support agencies were unsure how much financial assistance to offer Botswana at this time. However a number of agencies provided support for upgrading hospitals, including equipment supply. Unfortunately, Botswana faced serious problems with the equipment in its central referral hospitals. For example, one hospital (in Francistown) had been upgraded with foreign assistance (from France) using inappropriate designs and imported fittings. The subsequent blocked toilets and cisterns could not be replaced with Botswanan products due to incompatible water entry and waste exit positions.[164]

For comparison, another sample taken was the equipment at one mission and mine hospital; Table 5.5 shows the condition of the 93 and 113 pieces of equipment examined respectively. The equipment at the mission hospital was old but 71% was working satisfactorily, due to the simple nature of the technology involved, and funding available to send equipment away for repair or to pay private firms for maintenance. The equipment at the mine hospital was much newer and more sophisticated and 91% was working satisfactorily, due to the increased funding available, presence of a biomedical technologist on site, and willingness to fly in maintenance support from South Africa. Chapter 6 investigates in what way institutional organization issues contribute to the differences found.

TABLE 5.5: Sample of equipment examined at Botswanan non-government hospitals – 1992

Department visited	Total	Working ok & used[1]	Working ok can't use[2]	Working at fault[3]	Broken
Deborah Retief Memorial Mission					
Operating Theatre	8	8	–	–	–
CSSD	3	2	–	1	–
Laboratory	37	19	5	3	10
Maternity/Labour	14	10	1	–	3
Radiology	6	6	–	–	–
Dental Clinic	5	5	–	–	–
Minor Surgery	8	8	–	–	–
Eye Clinic	3	3	–	–	–
Laundry	4	4	–	–	–
Out-Patients Dept.	5	1	–	–	4
TOTAL	93	66	6	4	17
As % of total		71%	6.5%	4.5%	18%
Jwaneng Mine					
Operating Theatre	34	30	–	2	2
CSSD	3	3	–	–	–
Intensive Care Unit	4	3	1	–	–
Laboratory	23	22	–	1	–
Maternity/Labour	10	8	1	1	–
Radiology	8	6	–	2	–
Dental Clinic	20	20	–	–	–
Minor Surgery	5	5	–	–	–
Eye Clinic	2	2	–	–	–
Physiotherapy	2	2	–	–	–
Medical	2	2	–	–	–
TOTAL	113	103	2	6	2
As % of total		91%	2%	5%	2%

1. Performing as intended and being used.
2. Performing as intended, but unable to use because necessary inputs were unavailable, such as consumables, relevant skills, etc.
3. Not performing as intended or unsafe, but still in use because staff were unaware of the problems or desperately required some form of assistance from the equipment.

Botswana was receiving on-going support from NORAD to develop a national medical equipment maintenance service, including the establishment of four regional workshops. These MEMS workshops provided the MOH with 'in-house' maintenance capabilities for medical equipment (only) around the country. This could, in part, be the reason for the slightly improved status of medical equipment in Botswanan government facilities, compared to Zambia. However, for all other types of healthcare technology there were six different public sector maintenance bodies with partial responsibilities (see Chapter 6). This arrangement led to considerable conflict and affected the ability to undertake maintenance successfully.

Botswana's private sector had only recently become involved with healthcare technology, mainly through sales or maintenance rather than manufacturing. A small number of Botswanan companies simply acted as sales representatives for imported products; only two provided maintenance services. The more widely available resources in neighbouring countries were little used by the MOH.

5.1.3 Namibia in 1997

Namibia is a large country of approximately 825,000 sq.km with an estimated population of only 1.58 million which, in spite of rapid urbanization, is still mainly rural. Namibia is bounded by two major deserts, is the most arid country south of the Sahara, and lack of water is an ever present constraint. The potential for arable agriculture is generally limited to the north where water is less scarce, agricultural potential in the central regions is confined to livestock farming, while the arid south can only sustain sheep and goat farming. The population distribution reflected these facts with almost two-thirds of Namibians living in the northern regions and fewer than one tenth living in the southern regions.[73]

Namibia is well endowed with a variety of valuable minerals (uranium, diamonds, gold, etc), and industrial minerals (granite, marble, salt, etc), as well as mid-water and deep-sea fish stocks. In 1992, per capita GNP was US$ 1,670 (77th of 174 countries in *UNDP's 1995 Human Development Report*).[165] However, this average indicator of well-being masked one of the most skewed income distributions in the world; the richest 1% of households consumed as much as the poorest 50%. Whilst the better-off half of households consumed over N$ 20,000 (US$ 6,900) a year on average, the poorest quarter consumed only N$ 2,200 (US $ 760)[f]. International practice categorizes households for whom food consumption makes up more than 60% of total consumption as poor, and more than 80% as severely poor. By this measure, in 1993 47% of Namibian households were poor and 13% severely poor. The enormous differences in levels of human welfare amongst the population result from inequalities induced by discriminatory apartheid policies of the past. Consequently, in spite of Namibia's relatively high income per capita, it ranked only 108th in terms of the UN Human Development Index (which includes education and health indicators).

To the mid 1960s, most hospitals were outside the public sector, run mainly by churches and in a few instances by mines. The period to the mid-1980s saw a massive expansion in public (S.African government) hospitals, with large facilities built in 13 towns and three additional high-rise constructions. The period up to the early 1990s (during the fight for

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f. In 1992, US$ 1 = 2.9 N$ [166]

independence) saw a 'pulling-back' of the church-run sector with closure of many Roman Catholic hospitals and handover of six Lutheran ones to the new government. The resulting reaction in the state sector saw expansion of existing and construction of new facilities in seven towns and the opening of the first two private hospitals. By 1997, this relatively large hospital sector was under pressure; since independence (1990) the main focus had been on primary healthcare, and savings in recurrent costs were required to finance it. In 1997, there were 43 hospitals at district, regional and central level, 33 health centres with inpatient facilities, 225 clinics, and 900 health posts. The *First National Development Plan (1995 – 2000)* aimed to increase the number of clinics and reduce the number of hospital beds.[167]

During the preliminary country study visit (Section 3.3), it was found that the Ministry of Health and Social Services had no inventory of its equipment stock, and the Ministry of Works, Transport & Communication (MOWTC) had no inventory of the plant for which it was responsible within government health facilities.[72] Without these, or a longer visit to undertake detailed examinations, it was impossible to assess the percentage of equipment broken or its average age. However, survey data was obtained by gathering indicative figures from reports covering individual equipment areas. The results showed that:

* Nationally 70% of radiographic equipment was over 10 years old, with 4.5% of x-ray machines broken and only partial use possible for many additional items (*MOHSS's Master Plan Survey*).[168]
* 33% of infant incubators were not working at the Windhoek Hospital Complex (WHC) – the national and regional specialist referral hospitals in the capital (*WHC's Budget Motivation Report*).[169]
* At least 50% of laundry equipment was over 15 years old, with 50% broken countrywide (*Trend Line's Laundry Feasibility Study*).[170]

Without an equipment inventory, a maintenance record system, a planned preventive maintenance programme, or detailed interviews with staff, it was impossible for the MOHSS to assess the:

* % of equipment working at fault;
* % of equipment unused due to shortages of skills or personnel;
* shortfall of equipment, compared with standard lists, required to provide the basic health functions.

However, visits to facilities and discussions with staff made it possible to determine an indicative feel for these issues. One type of sample was taken for government facilities, where growing problems were found of equipment being used but not functioning effectively (such as autoclaves, anaesthetic machines, x-ray units, and defibrillators). Due to the shortage of equipment, items were moved around a great deal and subsequently damaged. The MOHSS was unable to maintain the equipment it owned, and the MOWTC was not replacing plant at the end of its life. Therefore the Government of Namibia was finding it impossible to sustain the previous level of health service offered. External support agencies had been spending money on equipment regularly since independence, but the proportion of their contribution to government was relatively insignificant (for example, they supported two out of 35 hospitals being upgraded).

For medical equipment maintenance, Namibia relied predominantly on only two workshops; one at the Windhoek Hospital Complex in the capital and one at Oshakati Referral Hospital in a north-western region. However these were designed to cater for their parent hospital only, and were overburdened with the extra workload from the rest of the country (ten regions). WHC also had a hospital furniture workshop for its needs only. The north-east had two mobile workshops for items of low technical complexity. Namibia had never developed a national support network for its medical equipment. In addition, the MOHSS was dependent on another ministry (MOWTC) and its budget for the maintenance of plant, autoclaves, buildings, etc. – see Chapter 6. MOWTC had many other clients, and different priorities from MOHSS, thus maintenance of plant and buildings was not taking place, neither was regular replacement of old equipment. MOHSS hoped to take over responsibility for this work but were in the midst of negotiations; in the meantime it had set-up a team of workhands based at Rundu Hospital to undertake minor maintenance and repair of plant at clinics in the north-east.

Namibia's industrial sector manufactured limited health products, with production concentrating on medical supplies and equipment assembly. Manufacture of equipment was limited to items of very low technical complexity (eg. developer tanks, monitor shelves, etc). Private contractors were used by MOHSS for repair of high technology equipment, and by MOTWC for plant. Namibian companies had close historical links with South Africa, and technical support could be flown in from this neighbour. Some PPM was undertaken by Namibian equipment suppliers for certain items, but such work was always limited by MOHSS' financial constraints (Chapter 9).

5.2 SUMMARY OF FINDINGS FOR THE STATE OF THE HTP SYSTEM AND SUB-SYSTEMS

This section reports on the situation in the three case study countries regarding the 11 component sub-systems (Section 4.3.1) and actor sub-systems (Section 4.3.2). Much data was produced, so this section summarizes and discusses the findings briefly. In the remaining Chapters of the Thesis, certain key issues are investigated in full. All three countries exhibited many, if not all, of the contributing factors which lead to problems with healthcare technology, with holistic HTP system failures. By taking a *Technological*

Systems approach to each country case study, I aim to find answers to my second research question:-

Q2 What are the key constraints to sustainability and what common problems persist?

5.2.1 Management and Planning Sub-System

In all three countries, although the MOH is the major health service provider, there was no specific healthcare technical department or ministry post with responsibility for equipment. However all three countries had fledgling maintenance teams whose head reported to senior officials in different divisions of the MOH; in this way advice on technical issues was sought albeit from fairly junior staff (see Sections 6.1 & 7.4). The only technical skills available were the small teams of technicians and artisans based at nearby hospitals. They concentrated on equipment maintenance and had only recently started to take on equipment management roles, without the necessary resources and skills. Botswana had moved the furthest in structural terms by setting up a network of four maintenance workshops around the country. Namibia had moved the furthest in terms of developing equipment procurement guidelines due to the central planning department overseeing hospital renovation projects.

No country had equipment policies, up-to-date inventories, development plans, or many of the other necessary management 'tools' and this led either to crisis management (Zambia) or planning 'in the dark' (Namibia). Usual management activities in other departments (gathering statistics, monitoring, supervision, feedback, quality control) were not applied to healthcare technology matters. Many uncoordinated players were found, both within and without the MOH, whose daily activities affected the life of equipment. Their responsibilities and interactions were very complicated, the worst case being Botswana. The management structure and roles of the institutions involved were found to be a key constraint to successful management of all other HTP components, and are investigated further in Chapter 6.

For government the management and planning sub-system was not in place for healthcare technology, in the way it was for other healthcare delivery activities. However, management and planning were in place for healthcare technology in the mine and some mission sectors.

5.2.2 Allocation of Financial Resources Sub-System

All countries faced a shortage of funds for equipment; none of them had a healthcare technology expenditure plan. All relied on a number of, mostly donor-funded, hospital development projects to cover part of their replacement needs; with no cover for the rest of their stock. All had severe problems with insufficient recurrent funds (for equipment operation and maintenance), often due to economic crises, but exacerbated by ad hoc budgeting and cutting of funds. It was difficult to ascertain what had been spent specifically on equipment. Without inventories, budgeting was simply guesswork. The shortage of funds, or the low priority placed on equipment, meant that money was limited for installation and commissioning, service contracts, training of staff, access to reference materials, etc. Financial planning thus forms a key constraint to successful implementation of all other HTP components, and is proposed as a key overarching theme to be investigated further (Chapter 8).

5.2.3 Selection of Technology Sub-System

The economic downturn in Zambia meant that acquisition of equipment had been sporadic and largely donor funded, providing no opportunities for systematic selection. A wide range of makes and models were present. However, in equipment areas where a few suppliers still operated locally (eg. x-ray equipment, infant incubators) there had been some de-facto standardization. The former Mechanical Services Department (of the Ministry of Works & Supply) had in the past a strong standardization policy so most boilers, laundry, and kitchen equipment were from single suppliers. Nevertheless, there had been no attempt by the health services to assess equipment. Donated equipment existed in wide variety throughout the health system.

Botswana provided evidence of the problems arising as a result of poor selection. A report on equipment purchases for the newly constructed Nyangabgwe Referral Hospital (*Barraclough*) stated that 20% of the equipment was unsuitable or incomplete, and quality was so poor that three years after commissioning much was falling apart and hazardous.[164] Examples of problems included: transport incubators which were not transportable, trolleys so narrow that patients fell off, ENT microscopes unsuited to surgery, and x-ray film filing cabinets which could not bear the weight of the films.

The MOH had established a multi-disciplinary Medical and Surgical Instruments and Equipment Committee to advise on the selection of equipment, with representation from central staff but not from districts. A series of large hospital upgrading projects gave no time to develop national standard equipment lists and specifications, rationalize the stock and its distribution, or consider routine requests. Health facility staff despaired that their requests would ever be answered.

In Namibia, by contrast, there was little evidence of problems of equipment selection due to centrally developed equipment specifications. The MOHSS was in a stronger position to negotiate with donors (Section 10.5). The technology present ranged from basic to highly complex; and in some instances user skills did not match the complexity involved. There was a problem of politicians expecting inappropriate sophisticated equipment. As standard specifications had been written, MOHSS felt there was no role for a Selection Committee. This left no purchasing policy or prioritization of funds.

The Namibian system was dominated by the centre, because regions had no technical staff. Selection was undertaken centrally without consultation with the regions, and only head office had sufficient access to product and supplier catalogues. As MOHSS used one- or two-year purchase contracts, there was an element of standardization for short periods.[73]

5.2.4 Procurement Sub-System

In Zambia, there were no well-developed plans or guidelines for procurement. Purchasing was run by crisis management, with routine user requests for urgent items going unheard for many years. Purchasing was mainly the responsibility of the parastatal Medical Stores Ltd with "instructions from the MOH", no relevant in-house technical expertise, limited consultations with users and technicians, and poor access to information for preparing purchase documents and evaluating tenders. Procurement tended to be slow and difficult. One hospital alone had a backlog of hundreds of unfilled orders.[69] Usually a simple 'shopping list' of items, with no other details, were provided to donors. Then they took over the procurement process with limited reference to the MOH.

In Zambia and Botswana, whether procurement was undertaken by government or donor agencies, there were problems with all stages of the procurement process – specification writing, the package of inputs, tender adjudication, sources of supply, delivery, storage, and payment. To illustrate typical problems, Table 5.6 details the problems found in Botswana when a referral hospital was upgraded with donor support. Namibia, by contrast, had developed generic specifications and purchase contracts that included the whole package of inputs, and availability of maintenance support in Namibia was a pre-requisite. Problems only arose when decentralized bodies bought off contract, or donors insisted on goods from sources that could not provide maintenance support (Section 10.5).

Tender adjudication was governed in all three countries by Central Tender Boards which still resisted standardization attempts and veered towards cheapest bids, but moves had started in Botswana to allow arguments to accept the 'better package', and in Namibia to 'blacklist' poor performing tenderers. The long chain of logistical activities (letters of credit, freighting, customs clearance, warehousing, local transport, etc) varied depending on whether government, donors, or suppliers procured and organized logistics. The process involved many parties, was bureaucratic, problematic, and caused significant delays between placing an order and receiving the goods (as much as 6 – 12 months).

TABLE 5.6 **Lessons to be learnt from the Nyangabgwe Referral Hospital upgrading programme with regard to effectively procuring equipment**

Activity	Common Problems Arising	Examples
Writing Specifications	Full specifications not used	Equipment list of single line or word descriptions, used as specifications
	Specifications so poor that non-medical items supplied	Metallurgical microscopes, coca cola fridge for blood bank
	Descriptions so poor that items are not suitable for their intended use	Apnoea alarms unsuited to premature babies, suction units without pumps, unsafe resuscitation tables
	Consultant's advice ignored	Priorities ignored, action not taken
	Deficiencies in list of equipment purchased	During commissioning in 1988, serious shortfalls identified
	Not to international standard	Dangerous infant incubators
Contents of the Purchase Agreement ie the "Package"	Bought without accessories	No pulse oximeter straps, no ECG leads for paediatric patients
	Bought without manuals, or with manuals not in English	None for ethylene oxide sterilizer. Most manuals in French
	Complete equipment set not purchased	CSSD sterilizers bought without loading cars, so workload must wait for sterilizer to cool
	No replacement parts	No extra suction bottles
	No spare parts	None for CSSD autoclaves; supply difficult for ICU equipment
	Insufficient maintenance and tests tools	Defibrillator tester, diathermy tester, storage oscilloscope, etc
	User training not asked for although required	For CSSD washing machines, for ICU staff, for auto-sample system
	Maintenance support not asked for	X-ray machines, & many others, have no service contract
The Purchase Process, ie Formal Tender	Poor adjudication	Insufficient technical assessment and checks for compatibility with existing supplies
	Not considering life-time cost	Blood analyzer reagent too costly
	Not including package of inputs	See above
	No standardization	Various sources for an item even in one order. Further diversification in subsequent orders
	Incompatible items	Gastroscopes from one source, lights and cleaning brushes from another; they were incompatible
	Buy cheapest instead of best	Poor quality, lightweight items
Source of Supply	Some replacement items hardly better than original	Orthopaedic operating table
	Equipment not from stated manufacturers	Bronchoscopes
	Equipment not new when it arrived	Auto-sample system, bronchoscopes, paediatric resuscitation table
	Some equipment obsolete	Paraffin bath, blood warmers
	Poor quality of product	Transport incubators, operating tables, anaesthesia machines, X-ray machines. Items unsafe or unsuitable for use
	Users cannot review sources	No access to supplies catalogues, no MoH shortlist of suppliers
Delivery	Equipment is not what was stated on the carton	Laparoscope on outer box, ENT microscope on inner box, colposcope inside
	Shipping damage	Ethylene oxide sterilizer
	Some equipment never arrived	Some orders from CSSD, pharmacy, physiotherapy, and orthopaedics
Storage and Stock Control	Equipment arrives without warning and with no record of who ordered it	Laboratory equipment
Payment	Money was left over in the project budget of 1990, but equipment was not replaced	The consultants equipment report of 1991 was not acted upon

Poor procurement affects the other HTP components, and is just one example where donors are a key constraint. Thus, the role of external support agencies is proposed as a key overarching theme to be investigated further (Chapter 10).

5.2.5 Preparation for Technology Use Sub-System

In Zambia and Botswana, little use was made of manufacturers or private companies to assist with site preparation, installation, and commissioning, except during facility construction. Thus in-house maintenance organizations had to undertake the work. Botswana, again, was hindered by the number of public sector bodies involved for healthcare technology, with a major headache to get collaboration on site. In these countries, examples could be found of equipment which had never worked; pieces of equipment which no-one knew how to assemble; and equipment installed in rooms with leaking ceilings, inappropriate electrical wiring, or of an unsuitable size – such as a phototherapy lamp in a premature baby room so small that it treated all the babies.

In Zambia and Botswana, the in-house maintenance organizations had no calibration or safety testing equipment. Whereas in Namibia such equipment was reportedly applied by the central workshop on sophisticated equipment before distribution and issue. In Zambia and Botswana, staff reported limited training from suppliers in operation and maintenance. Instead (older) colleagues were meant to transfer skills informally. In Namibia greater use was made of training by central workshop staff or supplier companies. But there were still problems with transferring skills to all staff members, and equipment mis-use.

5.2.6 Continued Operation Sub-System

In Zambia, the severe shortage of equipment affected the practices and perceptions of staff, for example: some locked items away and used them infrequently rather than risk breakage; some invested considerable time and energy in ad hoc fund raising yielding little impact on services; some did not believe that equipment would work so never attempted to use it, even if it functioned perfectly. With crisis management and funding, much equipment had been waiting for consumables and replacement accessories for so long that in the meantime motors had seized, plant corroded, tubing become brittle, and gaskets perished, etc. Botswana also had shortages and problems with consumable items, due to the complex network of organizations responsible for ordering different types of goods. As Namibia did not gather equipment statistics and had no inventory, the MOHSS could not say if equipment was unused due to shortages of consumable inputs, but thought it likely.

Equipment care, cleaning, calibration, and 'fine-tuning' skills amongst users varied widely across the health facilities in Botswana and Namibia, and were limited in Zambia; the loss of

TABLE 5.7 Examples of safety issues at government district hospitals in Botswana in 1992

Department	Safety Practices	Safety Hazards	Regulatory Body
Hospital in general	• Collection of sharps • Plastic bags for collection of biological waste • Biological waste incinerated	• Sharps not always in safe containers • Poor use of colour coding of plastic bags for biological waste • No safeguards for dig and burn method when incinerator broken • Blood poured down drain • Only NRH staff given Hepatitis vaccines	• Only 1 infection control officer for country (at NRH) • Only Athlone Hospital has developed a code of practice for itself • Need infection control meetings and training • Health Inspectors do not visit regularly and have limited knowledge • National Infection Control Committee for control of outbreaks
X-ray	• Use film badges, send to SA monthly • Use lead screens • Use lead aprons • Send fixer for silver recovery	• Insufficient or poor lead lining to rooms • Poor use of gonad protectors • Developer poured down drain • No QA for equipment or results • No monitoring of radiation levels • No biological monitoring of staff • Unsure of cleaning methods	• None in Botswana • No meeting of radiographers nationally
Laboratory	• Use standards from NL to calibrate equipment, but not all staff know how to • Some staff use gloves for testing samples • There was a programme of quality control of lab results by NL	• Mouth pipetting • Staff will not use gloves for taking samples • QC programme has stopped • Food in laboratory • Samples kept 1 week • Unsure of cleaning methods • Do not decontaminate equipment	• National Laboratory • Supervision visits very limited • No meeting nationally • NL Public Health role affected by workload of standard tests
Operating Theatre	• Do anti-static cleaning • Regular cleaning of theatre and equipment	• Engrave surgical instruments • Do not decontaminate equipment	• Medical & Dental Association • No meeting nationally of theatre staff
CSSD	• Use temperature tape	• Sterile and unsterile products not always separated	• Medical & Dental Association • No meeting nationally
Maternity	• Wear gloves for deliveries	• Have to use mouth mucus extractors • Unsure of cleaning methods • Do not decontaminate equipment	• Medical & Dental Association • No meeting of Midwives nationally
Dental	• Use film badges, send to SA monthly • Regular cleaning of equipment • Some staff use gloves	• Do not use goggles • Only staff at NRH vaccinated for Hepatitis • Not included in infection control meetings	• Medical & Dental Association • Oral Health Service • Code of Practice on Infection Control • All dental staff meet annually, RDOs meet more often

Key:
NRH Nyangabgwe Referral Hospital
NL National Laboratory
QA Quality Assurance
QC Quality Control
RDO Regional Dental Officer

such skills was exacerbated by high staff turnover. Hospital management teams had not developed sufficient schedules and timetables for these activities, especially as so few possessed operator manuals. A number of departments stated that they did not clean equipment for fear of damaging it, and none of the departments decontaminated equipment before sending it for maintenance. The insufficient care and calibration led to many examples of faulty and unsafe equipment in use.

Discussions with staff, in all countries, consistently showed that there was a lack of understanding and insufficient safety guidelines in the key equipment-related safety fields, such as infection control, waste disposal, sterilization, radiation, laboratories, electricity, fire, machinery, chemicals, gas, security, etc. Table 5.7 details the problems found in Botswana at government district hospitals.

In all three countries, the treasury regulated disposal of government property, Boards of Survey condemned equipment, and regional or district local government officials disposed of it. Nowhere were these methods working, with graveyards of old and broken equipment. No write-off processes automatically triggered a procedure to replace the equipment.

5.2.7 Maintenance and Repair Sub-System

Most first-line maintenance and repair was the responsibility of government personnel. In all three countries, few public sector workshops for medical equipment and limited national support networks existed, except in Botswana (see Section 5.1). Healthcare technology was maintained by various public sector organizations. Namibia and Botswana suffered from fragmented organizations, complexities of coordination and communication, and low priority of health requirements. Both countries were considering how the MOH could take over. Zambia had gone the furthest in disbanding other agencies, and placing engineers in charge of workshops covering the whole range of maintenance disciplines. Then maintainers worked towards the same goal – the well-being of the hospitals, and their various skills were used wherever they were needed.

However, effectiveness was resource limited. The tables in Section 5.1 show that all countries faced problems of equipment that was broken or working at fault. Most public sector maintenance teams (whichever organization they fell under) had similar problems and constraints:

* their role and worth not recognized by their ministries;
* insufficient budgets, workshops, tools, test equipment, and transport;
* their advice not sought or ignored during purchasing, leaving them problematic equipment to maintain;
* ministries resisted purchasing spare parts with equipment;

* insufficient staff, and difficulty obtaining recognition for their experience;
* difficulty finding training courses, suitable entrants, and scholarships;
* misuse by operators;
* insufficient technical manuals and databooks;
* poor maintenance management and limited record- keeping;
* vast distances to cover to maintain an aging stock;
* reacting to one crisis after another, and responding to breakdowns rather than planning preventive maintenance.

Certain categories of sophisticated equipment (eg. x-ray machines, laboratory analyzers, monitors, anaesthetic machines, lifts, laundry equipment) require support from private maintenance contractors. Few of these sorts of companies operated in the countries. Zambia's MOH had only three types of equipment on annual maintenance contract. Botswana's MOH made little use of the more widely available resources in neighbouring countries with only one annual maintenance contract. Namibia did make use of contractors in their own private sector and from South Africa. They all found contracts expensive, had vast distances to cover, and waited a long time for a response.

Other health service providers in these countries, however, managed to keep their stock of equipment in better working order due mainly to their better management and greater resources. No ministry of health had shared initiatives or tactics with these other health service providers. Also in each country other sectors using sophisticated equipment were managing to sustain their stock effectively, through various strategies (Section 9.5).

Maintenance is one of many services health service providers need from the private sector, and shows that the role of this sector is a key constraint. Thus, the technical support available from the private sector is proposed as a key overarching theme to be investigated further (Chapter 9).

5.2.8 Personnel Sub-System

There were shortages of health sector cadres in all three countries, which made use of substantial numbers of expatriate personnel (Section 7.1). The staff available were short of necessary skills for all the HTP sub-systems. All maintenance organizations, whether government, parastatal, or private, were short of skilled technical personnel and specifically engineers and managers. National industrial sectors and the external support agencies were short of sufficient technical skills to offer satisfactory support.

My fieldwork interviews (Section 3.3) suggested that morale was low amongst many health sector staff in all three countries, for a variety of reasons. Zambia's limited resources frustrated endeavours over a prolonged period, so that the level of malaise reported was the worst. Botswanan staff and managers reported a lack of self-motivation or pride in accomplishing something. It was difficult to be sacked and thus many people were skimping on their tasks. Namibian technical staff felt overloaded, and received little feedback or appreciation regarding what they did. Ministry of Health maintenance personnel do not have correctly labelled posts linked to entry qualifications, correct salaries, or promotion possibilities. Feeling unheard, a sense of hopelessness, and lack of support and supervision, meant small maintenance teams had low morale leading to a high loss to the private sector and its increased salaries.

A well-functioning system depends, in no small measure, on the numbers and types of personnel available to establish a national equipment management capability, along with training and skill development requirements (see Section 5.2.9). The absence of this capability forms such a constraint to successful implementation of the other HTP components that I propose it as a key overarching theme to be investigated further (in Chapter 7).

5.2.9 Training Sub-System

All three countries lacked suitable local training courses, foreign currency to send staff abroad, and the inclination to use the training resources of equipment manufacturers. During basic training, there was little exposure for trainee health workers to the sort of equipment they would have to operate and apply. There were no national training courses for public sector medical equipment maintainers, and hiring plant technicians and training them in-service was patchy. The countries found it difficult to send staff on international courses because few are available, trainees could not meet entry requirements, and donors provided limited scholarships (Section 10.7). Unlike clinical staff, the ministry of health maintenance personnel rarely appeared in national human resource development plans.

Training and skill development requirements of staff, in relation to their work with equipment, are essential for the well-being of the national equipment management capability (Section 5.2.8). This capability forms such a constraint to successful implementation of the other HTP components, I propose it as a key overarching theme to be investigated further in Chapter 7.

5.2.10 Technology Assessment, Research, and Product Development Sub-System

None of the countries undertook technology assessment in any organized way. In Zambia and Botswana, the ministries of health had not evaluated purchases, equipment in use, or levels of technology employed. There was no evidence that particular efforts were made to choose the most appropriate equipment. Namibia's MOHSS felt they did evaluate equipment before and after it was purchased, and made efforts to choose the most basic technology. They also subscribed to one of the international evaluation databases and some supplies publications, with donor funding. None of the countries participated in any international technology assessment programmes, or linked up with research bodies internationally or regionally (SSA). In addition, none of them undertook research and development on equipment products or equipment-related topics, nor were they collaborating with equipment manufacturers on product reviews.

5.2.11 Local Production Sub-System

There was limited manufacturing of healthcare products in these three countries. It varied from country to country, but mainly covered medical supplies (medical gases, intravenous fluids), assembly of equipment (beds, trolleys, microscopes), and manufacture of some items of low technical complexity (furniture, wheelchairs, developer tanks, prostheses). Locally produced goods made up a tiny proportion of the equipment purchased by health service providers; the rest being imported from abroad. Use of regionally produced products varied from country to country. Thus there were limited national capabilities for production, and weak national industrial sectors were facing constraints in the market place (Section 9.1.2).

5.3 CONCLUSION

The three case study countries are of similar geographical size, but Zambia has a different climate, size of population, and quantity of health facilities to Botswana and Namibia. Namibia appears to have the stronger industrial sector, and Botswana has the stronger financial base. However, they were all facing similar problems with healthcare technology. As much as 35 – 70% of their stock was out of order. However Botswana and Namibia had not yet reached the dire straits found in Zambia. None had strong equipment management structures within the ministries of health. All grappled with the problem of maintenance of plant, service supplies, and buildings by other ministries. All had tiny private industrial sectors to support healthcare technology.

The conditions in Zambian public sector health facilities had deteriorated the most, mainly due to the severe economic crisis. However with equipment of similar age, the mines were having greater success. This possibly could be attributed to the fact that ZCCM employed better 'technical management' learnt from their mining activities. It would appear that the slightly improved status of medical equipment in Botswanan government facilities, compared to Zambia, could be due in part to on-going NORAD support for a national medical equipment maintenance service, including the establishment of four regional workshops. The improved statistics at mission facilities in Botswana, compared to government facilities, appeared to be due to the funding available to send equipment away for repair or to pay private firms for maintenance. The excellent statistics at the Botswanan mine hospital appeared to be due to better funding, technical skills on site, and the use of maintenance support from South Africa. Namibia had no maintenance network but greater potential for private sector support. However it was known that, post-independence, the government had inherited an aging stock of equipment and with continued cuts in maintenance funding the amount of equipment breaking down was rising alarmingly. These findings led me to pursue the issue of institutional differences in the sustainability of healthcare technology, and Chapter 6 investigates in what way institutional organization issues contribute to the differences found.

The study of the HTP sub-systems in each country produced much valuable data, and highlighted that the countries were facing most, if not all, of the contributing factors described in Section 2.3, which lead to problems with healthcare technology and about which much has been written. They were also failing in the key components required for an holistic healthcare technology package as outlined in Section 4.3. The *Technological Systems* approach has enabled key constraints to be identified. In all three countries, the poor status of equipment was severely affecting the quality of health service that could be delivered. The analysis shows that the situation had deteriorated to such an extent partly because the systems for managing equipment had become so complicated that they were confusing and counter-productive.

The research additionally shows that lack of sufficient funds and absence of financial planning for equipment had a negative impact on all HTP components, and made a complex, difficult to manage situation, worse. To successfully implement the activities within the HTP system, an effective national equipment management capability is required.

The research shows that the strength and capacity within the private sector to support healthcare technology influenced the success of many of the sub-systems activities in each case study country. The analysis shows that the role and priorities of external support agencies also influenced many of the sub-systems. Thus the capabilities and strategies of these two players proved to have great impact on the successful management of the HTP sub-systems.

The analysis in Chapter 5 points to five fundamental overarching themes that re-occur and negatively influence many of the sub-systems of the HTP system, and thus the sustainability of the healthcare technology sector. Thus in answer to my second research question "*What are the key constraints to sustainability and what common problems persist?*", five key themes emerge from the analysis:

a. the institutional framework available for delivering healthcare technology management throughout the country (see Chapter 6);
b. the strategies taken to train personnel and develop a national technical management capacity (Chapter 7);
c. sufficient allocation of financial resources (Chapter 8);
d. the technical support available from the private sector (Chapter 9);
e. the role played by external support agencies (Chapter 10).

The subsequent Chapters of my Thesis provide an in depth discussion of these five overarching themes, to explain the reasons why so many problems occurred in the healthcare technology sector. Each theme is large and relates to institutional organization and development issues within a country. Thus my study of a technological system has led to the need to consider two further theoretical perspectives – an *Institutional Organization* approach and a *Development* approach.

CHAPTER SIX: INSTITUTIONAL FRAMEWORK FOR DELIVERING HEALTHCARE TECHNOLOGY MANAGEMENT

So far in this Thesis I have used my first theoretical perspective and taken a *Technological Systems* approach. The resulting analysis led to the identification of five fundamental overarching themes which seem to be key constraints on the sustainability of the healthcare technology sector. The nature of these constraints requires consideration of further theoretical perspectives that relate to institutional organization [g] and development issues. This Chapter starts the process of taking an *Institutional Organization* approach and looks at the first fundamental overarching theme – the institutional framework available for delivering healthcare technology management throughout a country. Taking this approach allows investigation of my third research question:-

Q3 What are the institutional organization constraints to building sustainability for healthcare technology?

Equipment management delivery structure and capacity both need to be present within health service provider organizations as well as elements of the national support environment, thus both areas were studied.

This Chapter continues the case study country research. Section 6.1 covers the complexity of the institutions involved in healthcare technology management activities in the countries, and Section 6.2 uses organizational learning and technology management literature to discuss the effects of such complex systems.

6.1 THE COMPLEXITY OF THE EQUIPMENT MANAGEMENT SECTOR

The equipment management sector involves health service providers, parts of the national support environment (such as various ministries and external support agencies), and the private sector (see Section 4.3.2). I concentrate here on the healthcare delivery structure of the primary players – the health service providers and major actors within the national support environment. All relevant institutions were interviewed as part of my fieldwork (Section 3.3).

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g. See footnote c. (Chapter 1)

6.1.1 Zambia in 1990

Ministry of Health – Zambia 1990

The MOH was the major health service provider but had no healthcare technical service department. As detailed in Chapter 5, equipment management was not formalized. All hospital matters fell under the Assistant Secretary for Hospital Services (AS/HS) in the Medical Care Administration. Most senior ministry staff were doctors with little or no management training. The AS/HS obtained technical advice from the Senior Medical Equipment Technician (SMET) who headed the small national medical equipment workshop, which was separate from the ministry.[69,159]

The SMET had a team of 13 technicians and artisans to cover the country (43 hospitals and 750 clinics). This team was weak, poorly qualified and resourced, and had a low level of managerial skills. For example, it kept no maintenance records other than a summary logbook of jobs. The MOH was in the process of incorporating plant technicians from other ministries into this unit. The unit was largely responsible for running the equipment system for the MOH; they tried to handle planning, selection, installation, user training, maintenance, spares ordering, and other equipment-related functions. Obviously they could not implement equipment management in health facilities on a daily basis. The MOH's Medical Equipment Committee was in charge of equipment policy, but had been dissolved, reconstituted, and met infrequently; decision-making resting with two or three senior Ministry officials.

Although there were moves towards decentralization, in 1990 decision-making, management, and organization remained over-centralized. Provincial Medical Offices administered healthcare delivery (but not facilities) in nine provinces, a similar structure existed in 58 districts, and discussions were underway for District Councils to run rural health centres. Recent moves to decentralize the hospital budgets to provincial level had resulted in problems and delays in payment, for maintenance for example, since hospital spending had to pass through the Provincial Medical Officer. The result was bureaucratic, cumbersome central government procedures, and no autonomy for health facilities to manage their affairs. As Section 5.2.1 noted, the MOH lacked equipment management tools and skills, and could give only minimal support and supervision to technical staff.

However there was one initiative that proved to be a good example for neighbouring countries (see Sections 6.1.2 & 6.1.3). The Ministry of Works relinquished its role of maintaining plant, and the MOH took on this responsibility by establishing multi-disciplinary teams of maintenance cadres. Thus hospitals had workshops, run by an engineer, covering the various maintenance skills required for the whole facility (Section 5.1.1).

Other providers of health services – Zambia 1990

Other major health service providers were missions and mines, but there was little co-ordination with government on equipment issues.

Mission health facilities. The Churches Medical Association of Zambia (CMAZ) represented 14 different denominational churches that supplied healthcare. They ran 30 of the 82 hospitals in the country, ten of which acted as district hospitals, and 64 health centres/clinics. They also undertook much of the training of nurses, midwives, community health workers, and traditional birth attendants. The government was subsidizing a substantial proportion of the costs of mission health services. When interviewed, CMAZ reported that every mission hospital was responsible for acquiring and maintaining its own equipment, without collaboration. Occasionally an overseas technician was hired to travel nationwide undertaking repairs and preventive maintenance on mission hospital equipment. In general, mission hospitals found it difficult to obtain spares, consumables, or maintenance support.

Mine health facilities. The major mining companies in Zambia provided a wide range of good quality health services, ran ten hospitals and 70 health centres/clinics. In 1990 these facilities were well managed and the equipment was old but in good condition. The reason for this improved performance, when the public sector was suffering severely, was a combination of better management especially 'technical management', using the following strategies (*Temple-Bird*):

* the establishment by ZCCM of a Medical and Educational Trust (MET) to run its health services and schools;
* maintenance philosophy from the mines transferred to equipment in hospitals;
* inherent technical capacity to care for mining plant and instrumentation directly transferred to hospitals, including planned preventive maintenance;
* use of various mine institutions to run training courses in plant maintenance;
* technical resources in mine instrumentation adapted to hospital needs through a specialized Instrumentation Training School;
* use of a strong management system, including performance indicators for staff, and code of conduct;
* procurement handled through offices overseas so that urgently needed spare parts were obtained within days;
* greater financial resources.[59]

MOH liaised with MET to use the advanced health services in some mine facilities, but reported little other collaboration or joint initiatives. For example the Instrumentation Training School successfully trained medical equipment maintenance technicians for the mines, and various mine institutions offered plant maintenance training, but no use was made of these resources by other health service providers – even though Zambia was one of the few countries in the region to have such training resources[h].

Private health facilities. In 1990, the MOH had announced the imminent lifting of its 15-year ban on private hospitals and nursing homes. There were numerous private medical practitioners, mainly in urban areas, who sent their patients to the mine or mission hospitals or to UTH.

Other government departments – Zambia 1990

a) Falling under the Ministry of Works and Supply

The Public Works Department (PWD) had maintainers responsible for the physical infrastructure of health facilities and all other government buildings. PWD did not have the funds, resources, or strategies to carry out its responsibilities.

b) Falling under the Ministry of Finance and Economic Development (MFED)

The MFED allocated equipment purchase and maintenance budgets to MOH, and maintenance budgets to the PWD. The National Tender Board rules and regulations governed the adjudication of bids, and still promulgated that the cheapest bid should win. The National Board of Survey was responsible for condemning written-off equipment and selling old government property, however many health facilities had decades worth of backlog clogging up their sites.

6.1.2 Botswana in 1992

A great many institutions were involved in equipment management in Botswana: the Ministry of Health, the Ministry of Local Government, Lands and Housing (MLGL&H), other health service providers, other government departments, local and foreign suppliers of goods and services, and donor agencies. The *Government of Botswana's O&M Report* highlighted the need to strengthen management of health services.[172] There had been some decentralization but only by handing over the running of district health services to another ministry – MLGL&H. Little use was made of the private sector to help with maintenance (Section 9.3).

h. Although this was recommended, within 5 years the facilities were closed and the opportunity lost. By the late '90s the mines were being sold off to private mining corporations who are not interested in the 'social' aspects of the ZCCM structure (housing, health, and educational facilities), are closing them and/or selling them off. Their future is in doubt.[171]

Ministry of Health – Botswana 1992

The Ministry of Health, the major provider of healthcare, was organized into seven main departments.[71] It had been set up on the understanding that it was responsible for the management of medical equipment, with Ministry of Works responsible for all other types of equipment. However this system was not working, so increasing responsibility for all equipment fell on health personnel. Thus the MOH was discussing the possibility of taking over control and budgets for all equipment. The seven MOH departments played overlapping roles in equipment management as follows:-

Technical Support Services' (TSS) major equipment-related areas of work were:

* The National Pharmaceutical Service that monitored pharmaceutical policy and quality control, and oversaw the Central Medical Stores (CMS) that purchased and distributed simple equipment for the public and private sectors.
* The National Health Laboratory Service that oversaw all laboratories, blood banks, and transfusion services, and advised on the purchase of laboratory equipment.
* The Medical Equipment and Maintenance Service (MEMS) that advised on the selection, use, and management of medical equipment. It ran the national medical equipment maintenance service by outreach, through two regional workshops and two satellite workshops based at hospitals. It had only seven technicians and 12 artisans under one expatriate engineer (Section 7.4.1) to look after 27 hospitals and 160 health centres, as well as increased responsibility for 'other' equipment.

As in many other developing countries, TSS admitted to being dominated by pharmacists and the problems of medical equipment management had been relegated a relatively low priority with no technical person based in the central ministry.

The establishment of the organization MEMS, approximately ten years earlier, was a good model for neighbouring countries even if it faced certain design constraints. But its headquarters was not based in the central ministry affecting communication and profile in the MOH. MEMS was responsible for coordinating maintenance countrywide through its network of workshops (developed with assistance from NORAD over several years), but it wished to widen its remit to include all aspects of equipment management. Surprisingly, many health personnel were unaware of the existence of MEMS nor understood the concept behind it – that the technicians were in a vertical structure that provided 'overall technical management' for the country as a whole, and were responsible for caring for equipment issues by outreach from the network of workshops. Managers of hospitals with MEMS' workshops on their premises, viewed the service as being for their exclusive benefit.

The Senior Hospital Engineer of MEMS was asked for technical advice, which was increasing the awareness of equipment problems within the MOH headquarters[i]. In 1992, he was a NORAD engineer, keen on hands-on maintenance but not the need for equipment management. For example, MEMS had not developed standard maintenance management tools. MEMS was meant to provide 'single technical management', but several other MOH departments acted autonomously with no reference to MEMS. Responsibility for different management activities in the HTP were spread amongst many different MOH departments with considerable overlap.

Hospital Services was responsible only for management and administration of government district and referral hospitals. Its Assistant Director chaired the Medical Surgical Instruments and Equipment Committee (MSIEC) which advised on the selection of (some of the) equipment purchased by the MOH.

Primary Health Care Services (PHCS) was responsible only for primary hospitals together with a number of preventive programmes and health promotion activities. The Units with equipment included: Oral Health Services, Special Services Unit for the Handicapped, Occupational Health Unit, and Family Health Services. All other primary care facilities (health centres and health posts) were managed by another ministry – MLGL&H.

Interviewees showed confusion about who was responsible for the equipment purchase for primary hospitals, and for primary healthcare clinics in other hospitals (eg. maternal and child health clinics in district hospitals).

The PHCS had developed some weakly coordinated maintenance resources outside MEMS. Family Health Services had an Extended Programme of Immunization (EPI) Unit that trained refrigerator technicians for the cold chain. The Special Services Unit for the Handicapped had an expatriate technician for maintaining audiology equipment, and an orthopaedic workshop employing maintenance staff.

Manpower was responsible for human resource management for professional staff only, ie. maintenance technicians. It also ran the National Health Institute (NHI) and Continuing Education Unit. The NHI reported the same confusion as PHCS regarding whether the MSIEC should be involved in its equipment selection. It was unclear who was responsible for maintaining equipment inside the NHI centres.

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i. By 1994, an engineer-manager had been recruited to work as a Chief Hospital Engineer based in the TSS of the central ministry to be in charge of management of all hospital equipment.[71]

Administration and Finance provided administrative support. It was responsible for human resource management for non-professional staff only, ie. maintenance artisans.

With a maintenance team made up of technicians and artisans, problems were reported because staff initiatives introduced by Manpower (for technicians) were not necessarily reflected by Administration and Finance (for artisans).

Supplies was an outpost of the Department of Supplies of the Ministry of Finance and Development Planning (MFDP). It procured equipment and medical supplies, distributed and stored them, and undertook stock control. Its Department of Finance and Accounts was responsible for financial management of the health service.

The Finance Officer in the MOH was seconded from the MFDP and managed the centralized financial control system. Health facilities did not control their own budgets for equipment, consumables, spare parts, or maintenance, were not consulted when budgets were prepared, not able to influence what was purchased on their behalf, nor told how much they had been allocated for maintenance.

National Health Planning Unit coordinated the preparation and implementation of the national health development plan, using planners seconded from MFDP. It managed all MOH investment projects, including equipment purchases, separate from routine purchases made by the departments of Hospital Services.

Planning, supplies, and finance officers were in short supply, and so were seconded from MFDP to ministries and rotated frequently. This caused problems because on arrival they were not aware of the health-related aspects of their work, learnt it, then promptly rotated out again.

There was no decentralization of responsibilities to health facilities; all issues were planned and managed centrally. Training of health managers had only just begun. During the case study, I found that 'hospital management teams' (medical superintendent, matron, and administrator) were unaware of the state of equipment in their own facilities. This team accompanied me on my inspection and discovered many equipment-related problems, and procedures of which they were unaware.

Ministry of Local Government, Lands & Housing – Botswana 1992

District and town councils had statutory responsibilities in public health. Through decentralization initiatives, they planned and managed primary healthcare activities in their territory and owned and operated two-thirds of the country's clinics and all its health posts.

The health departments answered to the head of their district or town council, who reported to the MLGL&H. District health services controlled their own staffing, equipment, drugs, and other inputs. However, the MOH had overall responsibility for the quality of the country's health services. It gave direction and monitored implementation of health sector strategies at district level through its Primary Healthcare Support Unit.

District and town councils used the government-wide systems of supplies and maintenance. They procured most goods through the MLGL&H Supplies Unit and obtained drugs and basic equipment from the CMS. The relative roles of the council maintenance department, MEMS, and other government maintenance bodies varied from district to district.

Decentralization was proving problematic and several management analysis reports had been commissioned to review the process. Co-ordination between the MOH and district and town councils was complicated by having two ministries involved. Some equipment management problems persisted. For example as *Otukile & Manyathelo* report, the standard list of clinic furniture, equipment, and supplies which had been prepared by the supplies unit of the MLGL&H had not been made available to the MOH even though it was the body responsible for purchasing the equipment.[173] Also, *Molelekwa* reported considerable confusion about the relative responsibilities of the four government maintenance bodies covering clinic equipment.[174]

Other providers of health services – Botswana 1992

There was little communication concerning healthcare technology between the MOH and mission, mine, defence force, and private medical services. When interviewed, they all wanted more information about each other's policies on standardization and preferred types, safety protocols, and maintenance and training resources. The other health service providers wanted to participate jointly in activities such as maintenance initiatives, training opportunities, and seminars; but MOH had not disseminated strategies or shared information.

Mission health facilities. The Association of Medical Missions of Botswana (AMMB) was an umbrella organization under which three missions of different denominations co-operated. Each ran one hospital and several clinics. Each hospital operated independently concerning equipment. There had been no attempts to standardize equipment or to manage maintenance jointly. The AMMB, with the German church organisation Centrum für Internationale Migration und Entwicklung (CIM), had employed an equipment engineer to support and coordinate maintenance and maintenance training. When interviewed, he reported that the better state of mission equipment compared to government was due, in part, to the basic nature of the equipment that was technologically simple (Section 5.1.2).

Mine health facilities. Two mine organisations ran three hospitals and a number of clinics. Each facility acted independently regarding equipment. There were no attempts at standardization or group negotiation of deals. Whilst hospital buildings and plant were maintained by mine staff, medical equipment was normally maintained on a contract from South Africa. One hospital (Jwaneng) had a dedicated biomedical technologist.

Defence Force health facilities. The Botswana Defence Force (BDF) had several health facilities for members of the forces and their families. Although these were called 'clinics', the one in Gaborone had a theatre, laboratory, and x-ray, dental, and physiotherapy facilities. The purchase of equipment was organised by the BDF Procurement Unit. Although doctors were involved in discussions on equipment choice, they reported having no final say regarding the models bought.

Private health facilities. There was one new private hospital in Gaborone that had its own biomedical engineering technologist. There were a number of private laboratories.

Other government departments – Botswana 1992

a) Falling under the Ministry of Works, Transport, and Communication

Department of Architecture and Building Services (DABS) was responsible for design, upgrading, maintenance, and budgeting for all government buildings from its headquarters. Through its depots around the country, it was responsible for upkeep of buildings, water reticulation equipment, drains, plumbing pipes and fittings, and fixed equipment (towel rails, doors, mirrors, etc.).

Department of Electrical and Mechanical Services (DEMS) was responsible for design, new works, maintenance, and budgeting for electrical and mechanical services in all government buildings from its headquarters. Through its depots around the country, it was responsible for upkeep of common specialized equipment such as air-conditioning, refrigeration, steam boilers, kitchen equipment, electrical reticulation of buildings, fire detection equipment, electricity generators and motors, coal installations, laundry equipment, cold rooms and mortuaries, water pumps and heaters, lighting and paging systems.

Central Transport Organisation provided, fuelled, and maintained vehicles for all government departments, through countrywide workshops.

b) Falling under the Ministry of Finance and Development Planning

Department of Supply purchased, controlled, and budgeted for items commonly used by government from its headquarters, and maintained wooden furniture and office equipment (electrical) through two workshops.

The Central Tender Board oversaw and adjudicated all bids for the supply of goods to government. Its mandate was to ensure value for money.

The Government Computer Bureau oversaw the computerization of all government offices and facilities, and were working with the Central Tender Board to try and standardize the procurement of computer hardware and software.

c) Parastatal bodies

Agencies such as the *Electricity Supply Commission* and *Water Utilities* maintained service installations up to the boundary of any health facility. *Botswana Telecommunications Corporation* oversaw the provision, connection, and maintenance of telephone services inside health facilities.

Thus, Botswana had many departments in the MOH and elsewhere involved in equipment management. MEMS was not in a position to wield overall technical management, and the idea of one overarching equipment delivery plan was impossible. The situation was so confusing that the health workers interviewed no longer knew how the system worked. Table 6.1 shows the many different sources of supply for equipment (and request routes) that the analysis identified that staff had to use if they needed different types of equipment.

Health workers had as many confusing sources of supply and request routes if they needed maintenance support. Due to the number of bodies involved, there was an overlap of skills and extreme territorial attitudes. It would appear this situation arose as a colonial legacy, and strange anomalies existed in the demarcation of maintenance responsibilities. Table 6.2 shows the analysis identifying that the differing responsibilities of each body is not divided rationally. MEMS had to take on tasks that no other agency was carrying out. It is a complicated network, and all the staff interviewed, whether administrative, clinical, or technical, were unclear about the details. Several meetings were required to establish who was responsible for maintaining which type of equipment. Equipment was discovered that did not fall under any existing maintenance arrangement; one prime example was fire-fighting equipment. Also, it was unclear when staff should contact the local or central branch of a maintenance organization.

TABLE 6.1: **Variety of sources of supply for health facility staff – Botswana 1992**

Type of equipment	Local staff to whom request is made	Central body to whom request is sent
New capital expenditure	Senior Medical Officer or no one at hospital	Ministry of Health Hospital Services Division
Replacement medical equipment for most depts, furniture & all general supplies	Supplies Officer	Ministry of Health Supplies Division
Typewriters, wordprocessors, photocopiers, calculators, etc	Supplies Officer and local Supplies Directorate workshop	Supplies Directorate Head Office, and MOH US/HA
Drugs, instruments, medical supplies, & some equipment such as sphygmomanometers, gas gauges, stethoscopes	Pharmacy staff	Central Medical Stores (CMS)
X-ray accessories	Pharmacy staff	Central Medical Stores
New laboratory equipment and supplies	Laboratory staff	National Laboratory, and Central Medical Stores
Refrigerator, electric geysers, air-conditioners, kitchen & laundry equipment	Local DEMS depot	DEMS Head Office, and MOH
Bathroom fittings, doors, gas geysers	Local DABS depot	DABS Head Office, and MOH
Dental equipment & supplies	Regional Dental Officer	MOH/Oral Health Services Div.
Primary hospital equipment		AD/PHCS, Supplies Dir, CMS
Standard clinic equipment	MLGL&H/District Council staff	MLGL&H, CMS, Supplies Dir
Exercise equipment at PHC or hospital level	Community or hospital physiotherapists	SSUH admin. officer & AD/PHCS or AD/HS
Walking aids & orthopaedic equipment	SSUH admin. officer	AD/PHC
Audiology equipment	SSUH admin. officer	AD/PHC
Occupational health equipment, ie. testers, lung function eqt		WHO & AD/PHC
Health education graphics eqt: - camera, printer, computer - recorder, mixer, speaker	Head of Graphics No one	Head of Graphics No one
Vaccine refrigerators	EPI/CDD	UNICEF & CMS
MCH eqt, ie. examination lamps, sphygmomanometers, etc	Family Health Services (FHS)	UNICEF
Growth monitoring scales	Food & Nutrition/FHS	UNICEF
NHI eqt, ie. for general teaching & for laboratory, pharmacy, nursing & dental courses	Head of NHI	US/Manpower, Head of NHI, & Supplies Directorate
MEMS maintenance tools & eqt	SHE/MEMS	AD/TSS
Computers	US/HA	Government Computer Bureau

Key:-
US: Under Secretary
AD: Assistant Director
SHE: Senior Hospital Engineer
HS: Hospital Services
FHS: Family Health Services
NHI: National Health Institute
Dir: Directorate
HA: Health Administration
PHCS: Primary Healthcare Services
TSS: Technical Support Services
MEMS: Medical Equipment and Maintenance Services
MCH: Maternal and Child Health
CMS: Central Medical Stores
DABS: Department of Architecture and Building Services
DEMS: Department of Electrical and Mechanical Services
MLGL&H: Ministry of Local Government, Lands, and Housing
SSUH: Special Services Unit for the Handicapped
EPI/CDD: Extended Programme of Immunization/Cold-chain Drug Delivery unit

TABLE 6.2: **Anomalies in the demarcation of maintenance responsibilities – Botswana 1992**

Type of equipment	**Organization undertaking maintenance**
1. Water Pipes & associated equipment	
- up to 50mm diameter carrying cold water	DABS
- greater than 50mm diameter carrying cold water primary supply up to pressure reducing point (may be in or outside the hospital fence)	Water Utilities
- greater than 50mm diameter carrying cold water after pressure reduction point	No one
- carrying hot water generated by steam	DEMS
- carrying hot water not generated by steam	DABS
- cold water tank	DABS
- cold water tank at new Nyangabgwe referral hospital	No one
- cold water tank controls at Nyangabgwe	MEMS
2. Furniture and Fixtures	
- wooden and fixed	DABS
- wooden and mobile	Supplies Directorate
- wooden and mobile at Princess Marina central referral hospital in the capital	MEMS
- metal and fixed	DEMS
- metal and mobile	MEMS
3. Gas Equipment[1]	
- using medical gas	MEMS
- using domestic gas in the kitchen	DEMS
- domestic gas water geysers	DABS
(1. but electrical water geysers	DEMS)
4. Electrical Equipment	
- electrical equipment for medical use	MEMS
- electrical equipment for office use	Supplies Directorate
- electrical equipment for kitchen/laundry use	DEMS
5. Lights	
- normal room lighting	DEMS
- operating theatre lights, fixed	DEMS
- operating theatre lights, mobile	MEMS
6. Telephones	
- telephone for an external line	BTC
- telephone for an internal line	BTC
- telephone for the internal intercom and paging system at the new Nyangabgwe hospital	MEMS
7. Dental Equipment	
- dental compressors	DEMS
- other range of dental equipment, instruments, and x-ray machines	MEMS, South African contractor, or No one
8. Physiotherapy Equipment	
- electrical equipment	MEMS
- exercise equipment in hospitals	MEMS
- exercise equipment in the community	No one
9. Various PHC Units Equipment	
- wheelchairs	MEMS and Lions Club
- orthopaedic supports	Orthopaedic workshop in Gaborone
- orthopaedic workshop equipment	MEMS, DEMS, South African contractors
- audiology equipment	SSUH's audiology technician
- MCH and clinic equipment	MEMS
10. Refrigerators	
- for kitchens	DEMS
- for vaccines/cold-chain	FHS's EPI technicians
11. Assorted	
- equipment in the National Health Institutes which train staff	No one officially, MEMS sometimes assists
- occupational health equipment	No one
- fire-fighting equipment	No one
- Health education graphics cameras	No one, or South African contractor
- Health education radio studio	No one
Note: For any of these organizations, there are different contact routes through different hospital staff and either local or central depots	

Unlike Zambia that was developing multi-disciplinary hospital maintenance departments covering all maintenance skills for the hospital as a whole (Section 6.1.1), Botswana's system involved many maintenance disciplines from separate national bodies, that generally were not based at hospital sites. Maintenance organizations had separate goals and priorities, and for most, hospitals were not their main concern. Immense problems were reported concerning cooperation and coordination to get a job done, and arguments arose over who was poaching on whose territory, eg. it was necessary to get a DEMS electrician, a DABS plumber, and a MEMS medical equipment technician to turn up on the same day to install a dental suite. Many skills were duplicated.

6.1.3 Namibia in 1997

Namibia's civil service development relating to equipment management had many of the characteristics of those of Botswana – many institutions and more than one maintenance organization. The players involved in equipment management are: the MOHSS, churches, private health service providers, other government ministries and departments, suppliers, donors and funding agencies.[73]

Ministry of Health and Social Services – Namibia 1997

Table 6.3 summarizes the units and officials in the central MOHSS involved in making decisions that affect equipment. There was no national coordinating body within the MOHSS responsible for equipment management, no senior technical manager, and no national network of workshops for equipment maintenance. Equipment issues fell under the Division Planning that oversaw all new development projects. They had developed good equipment management tools such as equipment specifications and annual purchase contracts, standard hospital designs and equipment lists, and maintenance contracts. However, MOHSS had not developed a national structure to implement the 'tools', nor a network of maintenance workshops

The Clinical Engineering Technical Workshop (CETW) at the Windhoek Hospital Complex (WHC) had been designed to serve the two hospitals involved, but had taken over responsibility for organising equipment maintenance and repair for most of the rest of the country. The head of the CETW liaised with MOHSS on equipment selection, procurement and commissioning. The North-west Region's referral hospital also had a workshop that acted autonomously for equipment selection, procurement, commissioning, maintenance, and financing. Namibia had only three technicians, four artisans, and several workhands to look after 43 hospitals and 33 health centres (Section 7.4.1). Thus private sector maintenance support was used if funds were available. Equipment users and managers only sought technical advice from the CETW in a crisis.

TABLE 6.3: Units and divisions at MOHSS national level involved in equipment management – Namibia 1997	
Equipment management function	**MOHSS unit/division/programme**
Operation (users)	Family & Community Health programmes Public Health programmes Nursing Services Specialized Services Laboratory Services Radiographic Services Pharmaceutical Services Forensic Services Administrative Support Services: - Logistics - Auxiliary services - Waste disposal (incinerators)
Funding	Division Finance Division Planning
Selection Procurement Supply/Distribution	Tender Committee Clinical Engineering Technical Workshop at Windhoek Hospital Complex Division Planning Division Logistics Users
Maintenance	Clinical Engineering Technical Workshop at WHC Division Logistics Users
Personnel and Training	Clinical Engineering Technical Workshop at WHC Division Planning Division Human Resource Development Division Personnel Administration Users

Namibia had undergone some decentralization to four Regional Directorates but with no technical staff. However their responsibilities for equipment management were budgeting and financial control (some Directorates did more of this than others), and monitoring and supervision. There were moves to devolve power further to the ten regions, which were at different stages of establishment: some were not established at all, others were very well developed (eg. Erongo). The Regional Health Management Teams (RHMTs) also had no technical staff, but their responsibilities for equipment management were financial mostly, with some requisitioning, procurement, monitoring, supervision, and contract management. District Health Coordinating Committees (DHCCs) had no technical staff even with significant responsibilities for equipment management.

In the central ministry the relative roles of departments in equipment selection, procurement, maintenance, finance, etc were clear. However, at Regional Directorate, RHMT, and DHCC level it was unclear whether their equipment management roles were defined or understood. There had not been any exercises to develop general staff into equipment managers. With so few technical staff, technical management skills were lacking and it was reported that the decentralization of some aspects of equipment management (such as funding maintenance) had been premature, before there was a local understanding of the issues involved. This caused problems of confusion, delays, added bureaucracy, extended down-time for equipment, and hindered rational planning for equipment.

From interviews it was clear that there was a high awareness of equipment problems amongst users since they faced the issues daily, but at MOHSS decision-making level equipment took a low priority especially when it came to funding. There was a low awareness of the multi-disciplinary nature of managing equipment. Namibia had a low level of general health management as it did not train or uniformly employ cadre such as hospital administrators. It was proving difficult to improve management of equipment when management in general was not strong.

Other providers of health services – Namibia 1997

There was no official forum to regularly share equipment standards, norms, and procedures with other health service providers, but ad hoc liaison was reported.

Mission health facilities. The not-for-profit mission hospitals liaised with regional directorates regarding aspects of equipment management. There was a great deal of autonomy, and it was reported that mission facilities appeared to be over provided with equipment. They were autonomous in procurement, did not use Ministry contracts, and had non-standard brands of equipment. They contracted repair and maintenance services directly from the private sector.

Mine health facilities. The mine hospitals had contracted-out certain aspects of equipment management. They obtained considerable technical service and repair back-up from within the mining company. They rarely liaised with the MOHSS on equipment matters.

Private health facilities. The private hospitals in Windhoek had contracted-out most equipment management to the private sector, although one (Medi-Clinic) had a small in-house maintenance unit. They consulted with the CETW regarding certain technical issues.

Other government departments – Namibia 1997

Other government departments were involved in equipment management and their specific roles in equipment-related issues are described below. MOHSS' Division Planning reported that co-ordination with these ministries was poor and there was no established structure for inter-ministerial discussions.

a) Ministry of Finance (MOF)

Falling under the MOF, was the Tender Board which oversaw government procurement, adjudicated bids, and allocated tenders, and the Treasury which approved recurrent budgets. The main problem was lack of awareness regarding equipment and maintenance funding, leading to inadequate allocations for equipment replacement and maintenance to MOHSS and the Department of Works.

b) National Planning Commission Secretariat

This body allocated the government development budget to the MOHSS, coordinated donor activities, developed and implemented aid policy, and oversaw donor-funded projects.

c) Ministry of Works, Transport, and Communication

Falling under the MOWTC, the Department of Works (DOW) had three basic roles relating to equipment. It oversaw the construction and major renovation of government facilities. It repaired and maintained fixed assets in government facilities (including plant and service supplies). It was responsible for the Central Government Stores and the Supplies system that provided general furniture, household appliances, and other goods for government facilities.

The main problem was poor communication between DOW and MOHSS managers at all levels. When interviewed, MOWTC admitting having no inventory of the equipment it was responsible for, could not tell the MOHSS what % of the DOW budget was allocated for hospital equipment replacement and maintenance, and often cut the funding for the DOW so it could not do its job.

Although only two maintenance organizations were involved, Namibia was similar to Botswana in the sense that MOHSS was not in control of the buildings, service supplies, or plant of its own health facilities. They were at the mercy of another ministry (MOWTC) that was busy looking after all government buildings, and at facility level the different types of maintenance staff worked in conflict rather than collaboration. MOWTC was looking into ways in which it could change the way it operated[j].

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j. Under the MOWTC 2000 initiative, it is intended that the MOHSS will hold budgets for its own plant replacement, maintenance and repair and will be able to contract DOW (or any other body) to undertake the work. However this new arrangement is unlikely to be in place for another two years, and depends on MOWTC's ability to sell off a part of the Government's fixed property in order to raise a sum for investment that will finance the maintenance of the remaining facilities.[175]

6.2 DISCUSSION OF EFFECTS WITH SUPPORT FROM LITERATURE

During the research it became apparent that by studying the healthcare technology sector, I am considering both boundaried organizations and the broader category of institutions under market, state, and civil society frameworks (*Robinson et al*).[176] Thus the sustainability of the sector requires both institutional and organizational strategies, and the discussion from the literature bears this in mind.

When *Mytelka* reviewed progress with African industrialization over the previous 25 years, she stated that the variations in performance across and within organizations in African countries may be the result of differences in ownership structure, management capabilities, or in the environment which induces more innovative or productive behaviour at all levels of a company – managerial, technical, and line workers.[143] This in turn may translate into greater productivity as a result of better maintenance, work organization, quality control, and other non-quantifiable knowledge and motivational inputs. This Chapter investigates such a premise for the health sector, and studies the national institutional framework available within and without health service provider organizations in order to determine its effects on the delivery of healthcare technology management. It was discovered that the equipment management sector of the three case study countries was very complex, and many of the problems related to institutional organization issues which leads to my third research question:-

Q3 What are the institutional organization constraints to building sustainability for healthcare technology?

In the case studies, it was found that the concept of managing the healthcare technology sector was relatively new for the ministries of health. The research undertaken demonstrates that there were a number of major organizational constraints for effective healthcare technology management: i) the structure available for delivering it across the health service, ii) the technical management capacity amongst staff, and iii) the ability to retain these skills once gained. These failings were obvious in the large organizational systems of the ministries of health which are the main health service providers, however it became apparent that these failings also appear within many other health service providers and other parts of the national support environment.

6.2.1 The Delivery Structure

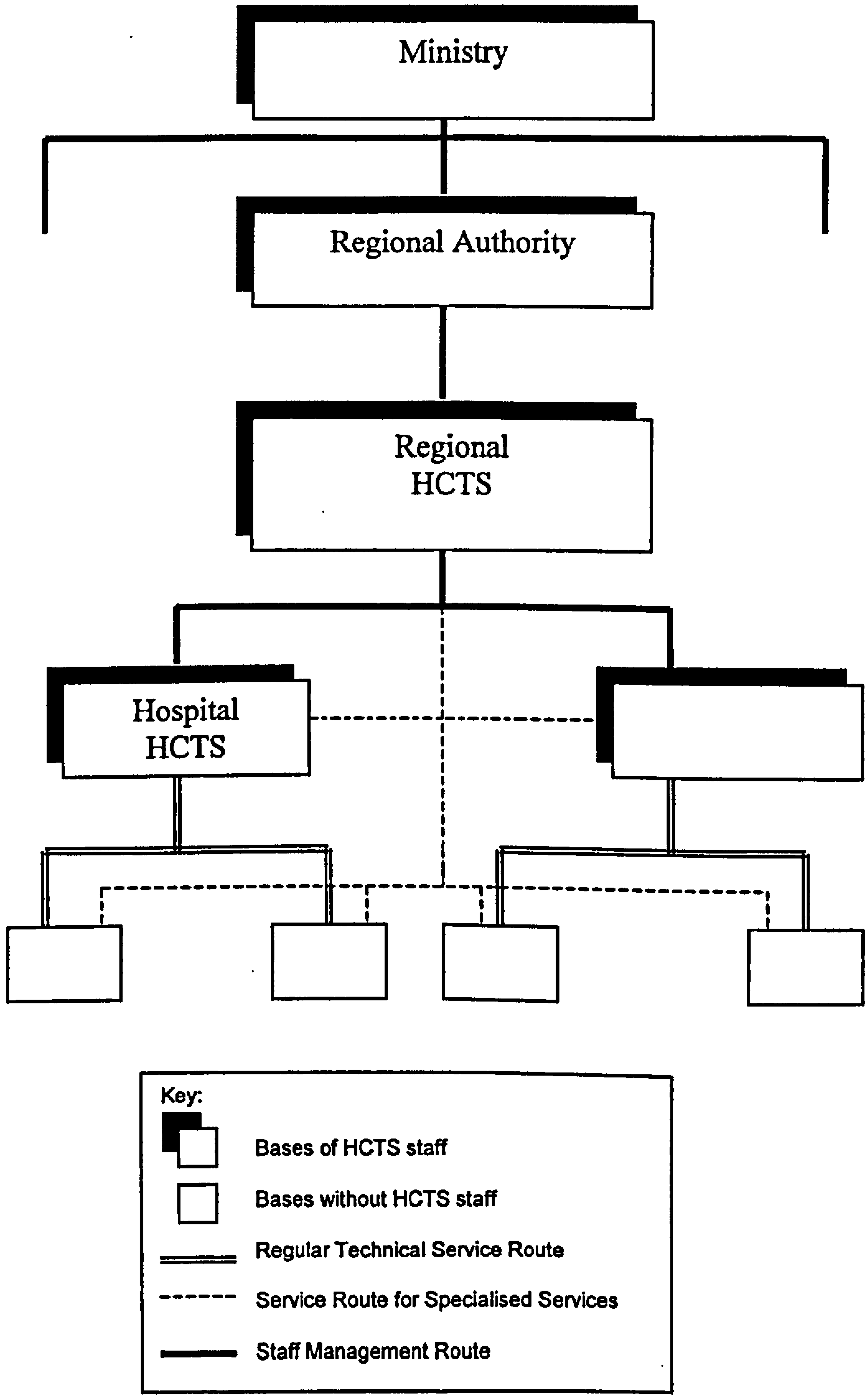
When *Cusumano & Elenkov* talked about the shortcomings of technology transfer literature, they warned that international researchers tend not to elaborate on how firms can best develop innovative in-house technological capabilities in conjunction with acquiring and assimilating outside technology.[142] But they report that technology strategy and management writers argue forcefully that managers must give priority to developing organizational capabilities in order to succeed in technology transfer. They describe these capabilities as including: the ability to separate different technological functions into different units or departments in the organizational structure as appropriate to the size and growth of the institution; to grant greater autonomy to technological functions as these gain prominence (without losing touch with service delivery goals); to facilitate technology information transfer across different departments; to develop technology evaluation services; to establish long-term links with technology suppliers, laboratories, universities, and industry associations; and to establish in-house training programmes.

It is possible to draw parallels with this viewpoint, taken from studies of productive industries, and the three case studies. A complex network of administrative units within the ministries of health were discovered playing a role in equipment management with little coordination. Botswana's MOH appeared to suffer the most with a complex spread of technological functions for equipment amongst too many different units for the relatively small health service (serving only 1.3 million people, with only 31 hospitals, and a small ministry). None of the health service providers in the three countries had developed an appropriate organizational structure or 'vision' for healthcare technology management, except for Zambian mine facilities. With a limited number of technical staff and virtually no technical skills amongst general staff, it was proving difficult to grant greater autonomy for technological functions as *Cusumano & Elenkov* proposed.[142] With such limited technical capabilities and no structure, there was no focal point or method for transferring technical information, evaluating technology, establishing links with suppliers, or for carrying out in-service training. Thus the health service provider organizations were unable to deliver effective healthcare technology management.

In 1987, the WHO published the idea of a Healthcare Technical Service (HTS) for ministries of health.[2] It promoted a number of concepts:-

* Equipment management involves a wide variety of functions (selection, procurement, training, safety, commissioning, etc) in addition to the traditional maintenance function.
* Countries and/or health service providers need an overall philosophy concerning their equipment and its management.
* Some form of national infrastructure is required to ensure that management functions are delivered at all levels.
* An HTS should be formed to operate from ministry level down to clinic level.
* There should be a national network of physical HTS centres (workshops) based both in hospitals, and at regional and ministry levels as shown in Figure 6.4.
* The HTS will contribute to good equipment management at all levels of the health service, by outreach from the physical centres.

FIGURE 6.4: Typical healthcare technical service (HTS) structure



Source: WHO, 1987, Inter-regional Meeting on the Maintenance and Repair of Healthcare Equipment, Nicosia, Cyprus 24-28 November 1986.[2]

* At facility level the HTS should provide service to all departments under a single technical management.

Although the WHO was aiming its advice to ministries of health, such concepts could be applied to any health service provider on a smaller scale. Such initiatives had obviously not occurred in the three case study countries. The health service providers studied had no coordinated structure for delivering healthcare technology management, except possibly the mine facilities in Zambia[k]. None of them had established a central equipment management unit to provide overall technical management under one professional department. Botswana had a fledgling network of maintenance workshops, but it had no link to the central ministry and was not delivering equipment management as well as repairs[m]. None of the other service providers had developed a network of maintenance/management workshops[n, o]. All were relying on a small group of technicians to try to run the national stock of equipment. Technical management skills were minimal, with so many players single technical management had not been achieved, and thus effective healthcare technology management was difficult.

It is apparent from the present research that the WHO's idea of an HTS within health service provider organizations does not go far enough. In the three case studies, it became apparent that equipment issues were affected by choices controlled by other ministries. Thus successful management of equipment would require the active support of a number of ministries, and sufficient inter-ministerial cooperation. Table 6.5 gives an indication of the range and scope of the role that other ministries and government agencies play.

With so many organizations involved, the research shows that getting repairs done can be a bureaucratic nightmare, cause delays and bad feeling. It is interesting that whenever external support agencies prepare projects addressing healthcare technology issues, they aim them at ministries of health (see Section 10.4). Whereas any strategies to improve equipment management also need to be addressed in the ministries of Works and Supply, for example, which also need to take an holistic technological systems approach to the equipment they manage, and develop an equipment management delivery structure within their organizations.

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k. See footnote h.(this Chapter)

m. In subsequent years, Botswana corrected this.[177]

n. By 2001, Zambia had no national equipment management framework, but large hospitals had independent workshops with some technical representation on hospital management committees.[171]

o. By 2000, Namibia's MOHSS had designed an organizational structure for its national equipment management programme which it hoped to implement.[178]

TABLE 6.5: The need for inter-ministerial cooperation

Ministry or agency	Example activities relating to equipment
Public Works/Construction	design of buildings construction and major renovation of facilities provision of service supplies and plant installation and commissioning linking delivery to construction progress maintenance and repair budgeting equipment management
Education/Higher Education/Vocational Training Authorities/Trade Testing Authorities	training users and maintainers curricula development integrating theory with on-the-job training rewarding experience with formal qualifications research and development
Finance	allocation of adequate funds (capital and recurrent) secured funding for long term development plans tender board rules payment authorization procedures supplies procedures disposal and sale of government property access to foreign currency
Trade and Industry	import licenses customs regulations standardization initiatives encouragement of private sector new relationship with manufacturers regional technology co-ordination
Planning	awareness of equipment policy and development plans aid policy and co-ordination of donors development budget allocations & donor-funded projects establishment of a stable market local production regional initiatives
Public Service Commission	career structures salary scales recognition of maintenance cadres and qualifications establishment posts
Tender Board	allocation of tenders/bids for procurement tender procedures tender adjudication principles recognition of the 'package' of inputs standardization
Supplies Authorities/Central Stores	supplies procedures stock control delivery arrangements provision of furniture and office equipment
Boards of Survey/District Council Authorities	condemning and writing-off equipment sale and disposal of equipment

In the organizational learning literature, *Cohen & Levinthal* propose that to develop innovative capabilities and be a 'Learning Organization', an organization requires "absorptive capacity". This is a measure of its ability to assimilate and exploit new information, which is largely a function of the level of its prior related knowledge. They feel that the sources of a firm's absorptive capacity depend on the structure of communication between the external environment and the organization, as well as amongst the sub-units of the organization, and on the character and distribution of expertise within the organization.[179] They state that an organization's absorptive capacity is not resident in any single individual but depends on the links across a mosaic of individual capabilities. However, the three countries were short of technical staff in general and healthcare technology expertise and knowledge in particular. This led to poor communication links between service provider organizations and external technical support agencies, and poor use made of private sector resources. In addition, there was a poor spread of technical skills within the organizations, and poor communication between the various internal administrative units.

Berggren studied the best organizational design to support learning, and although his examples were from the manufacturing sector, he covers some practices relevant to the public sector. He promotes: the reduction of the number of hierarchical levels and layers of managers between general staff and the central governing body; workers organized in teams with team leaders who communicate directly with managers, who in turn make up the bulk of the institution's management committee; participation by first-line managers in the central governing body in order to enable cross-team learning; methods of ensuring managers regularly gain first-hand experience "getting their hands dirty" doing the work of their staff in order to learn from the 'coal-face' and diffuse best-practice; as well as inter-team learning to find effective ways to diffuse methods and practices from high-performing teams to lesser performing units.[180]

Applying this to the equipment management context illustrates the need to raise the profile of technical staff within health service provider organizations. For many years, engineers working in developed and developing countries have been calling for the presence of technical voices in the organizational hierarchy of health service providers, in order to bring a technical viewpoint to decision-making usually dominated by medics and administrators.[2] Besides obtaining technical representation in the central governing body (such as the ministry), there is a need for access to decision-making bodies, a technical voice on health facility management committees, and teams of technical staff with effective managers. Once these structures are in place, it will be easier to develop strategies for enhancing feedback between managers and technical/general staff, ensuring managers do not lose touch with daily equipment problems, enabling technical staff to learn through peer group meetings and professional contacts. All such structures and strategies were very weak in the three countries studied; not only did the health service providers not have organizational designs which support learning, neither did the external support agencies (Section 10.2).

In order to develop and sustain such organizational structures, an institution needs to have sufficient staff with a technical management capacity. This has been identified as the second major constraint to the delivery of healthcare technology management.

6.2.2 The Technical Management Capacity

Cohen & Levinthal's discussion on absorptive capacity, argues that to integrate certain classes of complex and sophisticated technological knowledge successfully into an organization's activities, the organization requires technologists and scientists who are competent in their fields and familiar with the institution's idiosyncratic needs, organizational procedures, routines, complementary capabilities, and extramural relationships.[179] The health service providers studied had few technical staff to cover the numbers of facilities involved (Section 7.4), and since technical staff in other maintenance organizations were responsible for all government facilities they could not dedicate sufficient time to health facilities. In addition, the relationships and demarcations between the various organizations were so complicated, that it was difficult for staff to be familiar with the correct institutional procedures.

It wasn't until after the situation analyses were undertaken as part of the fieldwork methodology (Section 3.3), that staff reported becoming aware of how the different elements of the system interact. This is supported by *Berggren* who says that there is a logic to learning, which requires: i) the holistic principle – the importance of understanding the whole and the interdependencies of all constituent parts so that the learning process encompasses the work in its entirety; and ii) the reflective principle – the need not just for manual skills and rote learning, but also for intellectual understanding of the process.[180] In this way the organization will obtain staff skilled in problem-solving and questioning, who are more competent, more curious, and have more advanced professional knowledge. The case study countries had not pursued such a course to develop their technical staff or the technical abilities of their general staff.

This research suggests that not only are healthcare technology engineers required in health service provider organizations, they are also required in external support agencies which undertake equipment projects in the health sector (see Section 10.2). In addition, the research shows that there is a need for more general staff to gain a 'technical insight', and an understanding of the holistic nature of equipment management. On this point, *Cohen & Levinthal* determined that if the expertise of most individuals within an organization differs considerably from that of external actors who can provide useful information, some members of the group are likely to assume relatively centralized "gatekeeping" or "boundary-spanning" roles. Also, for technical information that is difficult for internal staff to assimilate, a gatekeeper both monitors the environment and translates the technical information into a form understandable to the rest of the group. However the ease or difficulty of the internal communication process depends on the group as a whole having some level of relevant background knowledge, and that shared knowledge and expertise is essential for communication.[179]

I suggest these three points from the literature imply: i) the need for in-house technical staff with skills in equipment management, who ii) will be the focal point for communication on technical matters with suppliers and support organizations, but also iii) the need to spread technical knowledge wider within organizations, both to ensure a general understanding of the issues, but also to develop 'healthcare technology managers' from other professions since there is a shortage of technical personnel. Over the past five years, the MOH in Ghana and Madagascar have been developing their national equipment management structure in this way. They have developed the first level of their national HTS – the basic equipment management teams at facility level (where there are no technical staff) – to comprise members of general staff (eg. nurse, administrator, anyone showing an interest in equipment) who will be trained in equipment management techniques.[181,182] When Namibia subsequently developed an organizational structure for equipment management, they recognized the impossibility of obtaining large quantities of technical staff and used these examples to propose facility equipment management teams of two general staff.[74,178] However, a major constraint for the three countries studied was their low numbers of managers in general (eg. hospital administrators, departmental managers, district directors), and it was proving difficult to import healthcare technology management activities into a workplace with a general shortage of management skills.

When studying the best organizational design to support learning, *Adler & Cole* stress that besides individual learning, organizational learning is also required whereby work groups learn from one another to facilitate continuous improvement.[183] To achieve this they state that certain practices are required, such as standardization of work methods in order to capture best practice, identify the source of problems, and facilitate the diffusion of improvement ideas throughout the organization. Such standardization will make everyone somewhat of a technology manager, and therefore the skill development strategies for individual workers should be managed as a component of this process, rather than as a way of maximizing personal opportunities. I have subsequently pursued this idea in my work by developing equipment management procedure manuals with clients.[178,184-186] As standardized work practices for healthcare technology management had not been developed in the three countries, it can be seen that technology managers had not proliferated and best practice had not diffused through the health service organizations.

In the technology management literature, *Moss-Jones* talks of ten interwoven themes which are essential for a learning organization as follows:-

> "In order to be a learning organization, the organization needs to be perceived with a systems perspective. The leadership group is the prime mover in establishing vision and identity, and modifying the internal culture. The vision must give high priority to people issues in order to maximize learning, for people are the vital element in learning. The ongoing learning needs to focus on challenging existing mind-sets, and developing creativity, adaptiveness, effective teamworking, and feedback. And taking all these together, it is argued that the whole organization needs to develop a culture which promotes all these themes continually.[187]

Although these ten elements exist in the three countries studied for some aspects of healthcare delivery, for healthcare technology management they were absent. The case study countries had not developed a holistic systems perspective for healthcare technology and the situation analysis was the first chance to investigate the multi-function nature of equipment management. As previously stated, there was no leadership group for equipment management that would be the prime mover in developing the technical vision. With limited technical staff and managers it was difficult to achieve effective teamworking and feedback. Thus for this field, there had been limited staff training, challenging of existing mind-sets, and developing of creativity and adaptiveness. Therefore in the sphere of healthcare technology management, the health service providers could not be described as learning organizations.

6.2.3 Institutional Memory Loss

Imai et al investigated successful Japanese technology management models in order to discover how companies learn. They propose that the know-how accumulated at the individual level should be transferred to other divisions or to subsequent projects within an organization and become institutionalized over time, and describe the process as:-

> "Members of an organization cannot only learn as individuals but can transmit their learning to others, can codify it and embody it in the standard procedures of the organization. In this limited sense, the organization can be said to learn. When certain organizational arrangements are in place, an organization will foster the learning of its members and take the follow-up steps that convert the learning into standard practice. Then it is functioning as a learning system, generating innovations."[188]

Although there have been initiatives over the past decade to try to educate government and donor staff with regards to healthcare technology issues, these bodies do not seem to be learning from their (or others') mistakes. With high staff turnover in public sector ministries responsible for healthcare technology and external support agencies who support this field, it is proving almost impossible to retain institutional memories for correctly handling technological issues. Having worked in this field for 18 years, I see that even if ministries of health and donors take on board some of the key holistic equipment management principles, this staff turnover means that within 3 – 5 years the principles are forgotten, projects experience the same old mistakes, and lessons must continually be re-learnt, all of which is a wasteful use of resources and initiatives (see Chapter 10).

Adler & Cole stressed that it is a dangerous assumption to presume that increases in individual learning automatically lead to an increase in organizational learning. They believe this is a fundamental fallacy, that organizational learning should not be taken as a given, and that managers must consciously work to create policies and practices that facilitate it.[183] Also *Adler & Cole* warn of the danger of organizational learning activities being run either as independent projects, and/or being staffed by personnel and external consultants engaged on a temporary basis. Because, with such temporary expertise, hard-won knowledge is too easily lost to the organization unless mechanisms are in place to ensure continued improvement.[189] This loss seems often to have occurred within the health service provider organizations and the external support agencies.

Adler & Cole state that learning to learn will take many years, and *Berggren* stresses the need to 'unlearn' old bad practices and get rid of previous conceptions and behaviour.[189,180] *Bateson* maintains that 'single-loop' learning occurs as people detect errors and modify their behaviours within the existing norms of the organization. The trouble is that those existing norms contribute to or even cause subsequent similar errors. 'Double-loop' learning occurs when organization norms and frameworks are questioned. In other words, the causes of problems are probed at a systems level above the level of the error. Double-loop learning is thus continually regenerating the organization: an important facet of the Learning Organization.[190] Thus, just such a *Technological Systems* approach as was taken during the situation analyses in the PhD field work visits, can help with the double-loop learning process and contribute to the regeneration of the institutions involved.

Cohen & Levinthal explain that accumulating absorptive capacity in one period will permit its more efficient accumulation in the next. If absorptive capacity is developed in a particular area, an institution may more readily accumulate additional knowledge in subsequent periods and exploit any critical external knowledge that becomes available. They warn that the cumulativeness of absorptive capacity suggests an extreme case of path dependence in which once an institution ceases investing in its absorptive capacity in a quickly moving field, it may never assimilate and exploit new information in that field, regardless of the value of that information. Consequently, a low initial investment in absorptive capacity diminishes the attractiveness of investing in subsequent periods even if the institution becomes aware of technological opportunities – a condition they term "lockout".[179] The health service providers and external support agencies risk being 'locked-out' of further technological understanding, by not setting themselves up as learning organizations which can assimilate and exploit technical information in the healthcare technology field.

Critical knowledge does not simply include substantive, technical knowledge; it also includes awareness of where useful complementary expertise resides within and outside the organization. This is knowledge of who knows what, who can help with what problem, or who can exploit new information. Close relationships with suppliers and a network of external sources of technical knowledge are pinpointed as important for technical innovation and strengthening of capabilities (*Cohen & Levinthal*).[179] The *Technological Systems* model that I have used stresses the importance of identifying the resources and capabilities available amongst the various categories of player involved, such as the national support environment and the international and national private sector (Section 4.3). I found that the health service providers were not aware of where knowledge resides within their organizations, nor what external resources were available or how to access them (Sections 9.2 & 9.3).

Adler & Cole report that "a consensus is emerging that the hallmark of tomorrow's most effective organizations will be their capacity to learn".[183] The healthcare technology development approach of health service providers must take this view into account. Therefore, it is interesting to see that the current restructuring and reform initiatives being undertaken by ministries of health and supported by donors, pay so little attention to the institutional framework, capacity, and resources required to deliver healthcare technology management. These initiatives: tend not to design an MOH organogram containing a technical management department linked to a network of workshops; move away from vertical programmes; prematurely decentralize technological functions to authorities without technical skills or understanding; do not address new strategies required to finance a sustainable technology stock, develop technical management capacity, develop management tools and a nationally realistic technical vision which autonomous bodies must also conform to. Is this due to the fact that such initiatives are advanced by medics, economists, and administrators in the absence of technical voices? Such development issues are discussed in subsequent Chapters of this Thesis.

6.3 CONCLUSION

This Chapter looks at the equipment management sector of health service providers (public, independent, private), and parts of the national support environment (mainly other ministries) with a role to play. In all three case study countries, the equipment situation appeared to have deteriorated so much, because of the lack of management per se but also, in the ministries of health, because the systems for managing equipment had become so complicated that they were confusing and counter-productive. Also, administrative arrangements between different ministries were colonial inheritances that had not stood the test of time, especially the role of the Ministry of Works in budgeting for, purchasing, and maintaining physical assets of other ministries.

The majority of the health service providers, and all the public sector ones, had no defined equipment management structure but had many different people from different administrative units playing uncoordinated roles – the identification and presentation of which was an original aspect of my research at the time of the case studies. The health service providers were short of technical staff with knowledge of healthcare technology, and were trying to manage an unknown quantity since they had no inventories of stock. All the countries had small equipment private sectors to offer support. The MOH in Zambia had not developed an equipment management structure. Namibia had developed some excellent management tools, but had not developed a management structure through which to deliver them. Botswana had made a start by building a network of four maintenance workshops, but had the most complicated system of uncoordinated administrative units involved in equipment activities. There is a need for a 'healthcare technical service' that delivers single technical management from central (ministry) to clinic level through a network of management/maintenance workshops and outreach services, via standardized procedures.

The ministries of health in Botswana and Namibia were grappling with the problem of how to ensure the maintenance of plant, service supplies, and buildings, which were the responsibility of other ministries. These external agencies had other priorities, limited funds, and poor management skills themselves. The involvement of many organizations frequently causes friction between bureaucracies, and demarcations established long ago result in overlapping responsibilities that cause conflict whilst leaving some equipment areas without maintenance cover. The worst example of a colonial legacy is the strange anomaly in Botswana where six maintenance organizations compete to perform badly in their task to keep healthcare technology functioning, and any rationale behind the arrangements can no longer be determined. By contrast Zambia had produced a potential model for other countries, whereby hospital maintenance teams with technical staff from all disciplines work together under one manager for the good of the hospital. Countries will need to consider in future whether to have major ministerial restructuring, or how to ensure the development of good equipment management delivery systems (an HTS) in the ministries of Works as well as Health.

Whilst public sectors struggled to achieve effective and continuous utilization of their equipment, some other health service providers ran facilities with a larger proportion of equipment functioning. The private facilities used their greater financial resources to purchase private sector support. The missions struggled without an equipment management structure or expertise, and either purchased technical support, relied on government assistance, or survived with occasional maintenance initiatives to support their less technologically sophisticated stock of equipment. The mine facilities on the other hand were generally coping better, by transferring their institutional organization strategies for the purchase, use, and maintenance of mining equipment to their hospital equipment. The best example was the ZCCM in Zambia, which demonstrated better technical management by having: a maintenance philosophy, technical capacity and training resources, strong personnel and general management, sound procurement with access abroad, and greater financial resources. Unfortunately, none of the ministries of health were collaborating effectively with other health service providers and joint equipment strategies had not been pursued. Thus several players in one country were trying to solve similar problems at the same time but in isolation.

When trying to successfully transfer and manage technology, the organizational learning and technology management literature emphasizes the need for an appropriate institutional structure, organizational capabilities and procedures, in-house technical staff, a wider spread of technical knowledge to general staff, assimilation of technical information, and links to external sources of expertise. However, in answer to my question " *what are the institutional organization constraints to building sustainability for healthcare technology?* " the analysis here identifies three major limitations:

- the absence of an equipment management delivery structure;
- the shortage of technical management capacity;
- institutional memory loss.

The literature also highlights that these limitations mean that the health service providers (and the ministries of Works) do not have a suitable organizational design to support learning, are not fostering institutional learning rather than individual learning, and therefore have not developed absorptive capacity and are not learning organizations in the field of healthcare technology management. Countries, and the donors which support them, need to look very carefully at their restructuring, decentralization, and reform programmes to ensure that they include initiatives to ensure they will be learning organizations for healthcare technology.

It is apparent from the research that the availability of suitable technical, managerial, and general staff, how they work in teams, and the training required is vital for effective equipment management, as well as to promote organizational learning. Thus this *Institutional Organization* approach is continued in Chapter 7 where personnel and knowledge issues are studied. In addition, there are lessons to be learnt in the case study countries from the initiatives taken by other industrial sectors when managing their high technology equipment (eg. mining instrumentation, distilling plant). Their ability to manage maintenance is one important element of managing technology, and their innovative work practices are discussed in Section 7.6. Also, there may be other maintenance resources within the public sector that have yet to be identified with the technical capacity to help with equipment management (eg. airforce engineers, research scientists, university maintenance staff, etc). Such sources of personnel and maintenance support are studied in Section 9.5.

Other constraints to the management of equipment and its viability, apparent from the research, are the shortage of funds, the support available from the private sector, and the role external support agencies play. Such capabilities, together with personnel shortages, are linked to development issues within a country. These issues will be discussed further in Chapters 7 – 10. Thus, a study of institutional organization leads to the consideration of my third theoretical perspective, and the need to take a *Development* approach.

CHAPTER SEVEN: DEVELOPING TECHNICAL MANAGEMENT CAPACITY

In Chapter 6, the institutional framework available for delivering healthcare technology management throughout a country was studied. In answer to my third research question "*what are the institutional organization constraints to building sustainability for healthcare technology?*", the analysis identified the necessity for 'learning'. The analysis also identified one of the major organizational constraints to effectiveness as being the lack of technical management skills amongst staff (Section 6.2.2).

When reviewing the unfulfilled promise of African industrialization over the last quarter of a century, *Mytelka* reported that perhaps the most distinctive single factor determining the success of technology transfer was the early emergence of an indigenous technological capacity.[143] *Cusumano & Elenkov* proposed that technological capabilities must be rooted, not in legal agreements or contracts for outside assistance, but in the knowledge, organization, and people that comprise institutions.[142] Chapter 6 concentrated on the organizational structure aspect. This Chapter looks at the people (Sections 7.1, 7.3 & 7.4) and knowledge (Sections 7.2, 7.3 & 7.5) aspects, as well as how they are managed by institutions (Section 7.6). Thus this Chapter continues the *Institutional Organization* approach, and concentrates on one aspect – the strategies taken to train personnel and develop a national technical management capacity. This topic was identified as one of the five fundamental overarching themes deemed to be a key constraint to the sustainability of the healthcare technology sector, in Chapter 5.

This Chapter continues the process of detailing the outcome of the country case studies. With assistance from technical training literature, it looks at the availability of personnel, training resources, working conditions, and constraints, all of which affect the ability to deliver the HTP system. The research shows that the availability of suitable technical, managerial, and general staff, how they work in teams, the training they receive, and their motivation is vital for effective equipment management (Chapter 6). The data gathered on personnel and training during the country research was predominantly based on the situation within public sector health services, and these form the main focus of the discussion with some comparative insights from other sectors.

Chapter 1 noted that capability constraints are a feature of a developing country. Thus by studying personnel and training issues, this Chapter also starts the process of taking a *Development* approach which is the third theoretical perspective used in my Thesis. This Chapter starts the process of introducing some examples of good and innovative work practices in an attempt to find answers to my fourth research question:-

Q4 Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?

7.1 THE AVAILABILITY AND CONDITION OF PERSONNEL

Section 5.1 detailed the results of the study into the state of equipment in the three countries, and many of the findings reflect on the level of skills available. In public sector facilities, anything from 15 – 40% of equipment was not in use because it was broken. Although many factors contributed to the inability to maintain and repair equipment, such as resource and infrastructure constraints (Section 5.2.7), one significant factor was the shortage of maintainers and maintenance skills. A smaller proportion of equipment (around 5%) was in fine working condition but was not being used; often this was due to the lack of skilled operators.

Section 5.1 also showed that a significant 25% (on average) of items were working at fault (although percentages varied considerably with equipment type), and considerable misuse of equipment reported. During the field research, equipment operators reported using equipment even though it was not working effectively, because they had no other option; for example operating tables whose position could not be altered, laboratory incubators that could only be used as driers. As discussed in Section 5.2.6, I also observed a substantial number of items working at fault without the staff being aware of substandard performance. The lack of preventive maintenance skills amongst technical and operator staff also meant that I found hazardous items in use, for example, infant incubators soiled with faeces and roofs leaking water into operating theatre lights.

All three countries had shortages of equipment required to deliver basic health functions (Section 5.1), with extreme examples such as a tertiary casualty department owning no resuscitation equipment, and only one suction pump, examination light, and examination couch. So conditions were having a serious effect on operator morale (Section 5.2.8). In Zambia, the department heads interviewed (Section 3.3) blamed the difficult working conditions and limited resources available. Staff described numerous self-help initiatives to improve their equipment on a small scale, long after most professionals would have given up, but the harsh circumstances had prevailed for so long that by 1990 they told me they were losing hope. In Botswana, many types of staff reported frustration at the equipment situation, but their sense of hopelessness that improvements would occur had led to apathy. This manifested itself as a loss of self-motivation and pride in accomplishing something, and I observed many people skimping on their tasks whilst proudly admitting that they knew it was difficult to be sacked from the public sector.

Technical personnel were overloaded due to staffing shortages that meant morale was low, exacerbated by the feeling that their work was not appreciated. Salaries were low, there were poor career structures with limited promotion opportunities, and minimal extra remuneration if successful; thus many staff resigned. Besides equipment users and maintainers, there was a shortage of the different types of staff required to undertake other equipment responsibilities, such as administrators, inspectors, tender adjudicators, etc.

During interviews in the three countries, a number of reasons were given for the examples of skills' shortage and loss of morale, and together with my experience in many countries, this leads to the identification of a number of key issues:

* shortage of user skills for equipment linked to training constraints;
* shortage of other types of personnel with equipment-related skills for holistic equipment management;
* shortage of technical staff linked to employment constraints;
* shortage of maintenance skills due to training constraints;
* shortage of adequate personnel management, personnel administration, and career progression.

These constraints need to be addressed by health service providers and other organizations if the HTP system described in Chapter 4 is to be delivered effectively. Thus I look at each of these issues in more depth in the subsequent sections of this Chapter.

7.2 AVAILABILITY OF USER SKILLS AND TRAINING OF USERS

The *World Bank* reported that one of the chief problems to overcome in Africa's health services is the shortage of sufficiently trained personnel. For example, the average population to doctor ratio in Africa in 1990 (at 10,800) was almost eight times higher than the ratio for all developing countries (at 1,400), with the averages concealing great variations between countries.[191] The Bank's data shows supply of trained personnel remaining woefully inadequate. From 1988 to 1992 fewer than 40% of African mothers had assistance from a doctor, nurse, or midwife during childbirth. By 2000, the *WHO* was still reporting that, in Sub-Saharan Africa in particular, limited training capacity and low pay for qualified health workers causes severe problems in service delivery.[21] Thus, it was important to examine the staffing situation in the public sector health services of the three case study countries.

The shortage of staff in the Zambian health sector had been documented in the government's *4th National Development Plan.*[161] For many types of cadre, the MOH had in 1987 only half the numbers they felt they needed according to their establishment and projected demands for 1993, as the indicative examples in Table 7.1 illustrate. Although there were 2,050 doctors and specialists, only 656 were Zambian nationals.[159]

TABLE 7.1: Indicative clinical staff supply & projected demand in Zambia & Botswana[1,2]						
	ZAMBIA			BOTSWANA[3]		
Category of personnel	Present in 1987	(of which non-citizens)	Demand by 1993	Present in 1988	(of which non-citizens)	Demand by 2002
Registered nurses & midwives	1,462		1,866	1,054	(85)	2,200
Laboratory technicians	129		235	91	(20)	209
Clinical officers[4]	1,438		2,423	–[4]		–
Doctors (medical specialists, medical officers, DMOs)	2,050	(1,394)	2,556	199	(171)	310
Dentists	21		125	21	(18)	35
Physiotherapists	71		71	10	(6)	25
Radiographers	144[5]		185	23	(10)	54

1. Sources: Zambian 1987 MOH Health Manpower Study[192] & GRZ 4th National Development Plan (1989-1996)[161]; Government of Botswana's Health Manpower Plan[193] & NDP7 (1991 – 1997)[163].
2. Wastage not taken into account.
3. In Botswana, the figures include the private sector.
4. Botswana did not appear to have a category of health personnel known as clinical officers.
5. In Zambia, the figures in 1987 included x-ray assistants who were being systematically replaced by radiographers.

Botswana had no local training for doctors, anaesthetists, radiographers, physiotherapists, occupational therapists, laboratory professionals, dentists, pharmacists, surgeons, clinical specialists, or nurse specialists. Therefore such cadres either had been trained abroad or were expatriates, and thus were in short supply. The government's *7th National Development Plan* noted the number of health personnel available in 1988 (including those in the private sector), along with the proportion who were expatriates, and compared them to the projected demand for 2002.[163] As Table 7.1 illustrates, the small health sector was reflected in the low numbers of personnel compared to Zambia, and again only about half the required staff were in post. The MOHSS of Namibia reported that all types of cadres were in short supply. The newly independent government was in its First National Development Planning period, undertaking a major restructuring programme of the MOHSS instigated by the need to decentralize health services to 13 regions. Thus the definition of core services for each delivery level, numbers and types of cadres required, and establishment posts that could be afforded were being reassessed.[194]

For training clinical staff, Zambia (1990) was the exception with various centres around the capital offering national training courses for doctors, nurses, midwives, clinical officers, dentists, radiographers, physiotherapists, pharmacists, laboratory officers (eg. the University Teaching Hospital, Chainama School for Health Sciences, Evelyn Hone College Paramedical Studies Unit), and additional mission facilities around the country for training nurses. Expatriate doctors were employed to cover shortfalls in graduate numbers from national courses. By comparison, the only basic training for health personnel undertaken locally in Botswana (1992) was for nurses, midwives, laboratory technician, pharmacy technician, dental therapist, and family welfare educators.[195] This training was covered by the five branches of the National Health Institute (NHI) around the country, two schools of nursing attached to mission hospitals, a nursing degree course at the University of Botswana, and a family welfare educator course at the Denman Rural Training Centre. Similarly in Namibia (1997), only basic training was undertaken locally, by the University of Namibia for nurses and radiographers, and the National Health Training Centre for different categories of assistant. Thus for Botswana and Namibia, all other types of cadres had to be trained at institutes abroad or contracted from abroad, therefore they had a great deal of expatriate staff in the health professions.

It is widely recognized within the healthcare technical profession that one of the biggest causes of equipment problems (more than 50%) is not failure of technology, but operator faults and misuse.[103,196-198] The UK government's *National Audit Office* even states that user errors accounted for 25% of fatalities and 33% of serious injuries reported in the period 1995-1998.[199] Another area of concern is equipment which is not used to its fullest capacity because staff do not know how to apply it clinically. It is essential to train health workers in a range of technology-related skills so that they can adequately perform their allotted roles. My experience in this field suggests they require several types of training: basic training for their profession (clinical or craft/trade skills), training in equipment operation (how to make it function), application of equipment (how to use it on patients or samples), cleaning, care, maintenance (users' PPM procedures), and safety procedures. Staff need to use the available equipment effectively and safely, and therefore need a full understanding of working in a technological environment (eg. the basic do's and don'ts, being competent with technology). This is especially the case in developing countries where staff may come from backgrounds and households where they are not familiar with common electrical/electronic equipment.

Health staff also need management and team working skills if they are to implement procedures involved in the HTP system. To achieve this range of technology-related skills, such topics need to be covered both during basic training before staff are hired, and throughout their career as a part of in-service training.

7.2.1 Basic Training

In all three countries, the national basic courses for health personnel provided clinical theory, but very limited training on technology use, care, safety or management, and health staff had little exposure to the kind of equipment they would find in the workplace. For example, in Zambia the Evelyn Hone College Paramedical Studies Unit had limited equipment that was old and often unrelated to items that staff would encounter on graduation (*Temple-Bird*).[200] The clinical managers interviewed reported that staff were short of the required technology-related skills for utilizing or applying ultrasound, blood gas analysis, ecg monitoring, defibrillation, etc, and scarcity of foreign exchange prevented attendance on specialization courses overseas.[69] In Botswana, the NHIs only had limited equipment of a simple type for trainees to work with.[201] For access to more sophisticated equipment, students were sent for practical exposure either to hospitals, the central laboratory, or a regional dental centre. However, both trainees and departmental staff stated that working departments found it difficult to allow unskilled trainees to operate equipment. Staff were unsure of the type of exposure and training they were meant to give trainees, and trainees were often just treated as onlookers.[71] In Namibia, there was little exposure for any types of trainees on the sort of equipment they would encounter. Student nurses went to the Intensive Care Unit in Windhoek Central Hospital (WCH) only once, or to theatre for only one short period in their four-year course, whilst some post-basic exposure was given to laboratory staff and theatre nurses.[73] All three countries found that expatriates and staff trained abroad were exposed to 'alien' types of technology to those found in post, and this early exposure led to a push by such staff for the purchase of these alien models.

Many types of equipment are operated by support staff such as laundry, kitchen, boiler, medical gas supply workers, etc. In all three countries, most of these staff had no formal training and relied on learning on-the-job from older members of staff, present when the equipment was first installed. Due to the size of secondary and tertiary facilities, many laundries, kitchens, etc, qualify as industrial facilities with heavy-duty electro-mechanical plant often with electronic control systems. Laundries also require technical knowledge of the application of hazardous chemicals. As *van der Linden* reported when studying laundry services in Namibia "to have a laundry supervisor with no formal management or technical skills base... assisted by an equipment attendant who is not fully literate... is irresponsible! Staff experimented with the use of acetic acid, concluded that 'the stuff burns like...', and left the rest of the stock unopened".[170]

Thus a major failing was the lack of integration of specific training modules on application, use, and care of equipment into basic-level training curricula for any type of health personnel, let alone management training on organizational procedures for the HTP system. This should not be too surprising as it often is not addressed in developed countries either. Having taught on a clinical engineering course at the Medical College of a London hospital, I know that over 11 years many attempts were made to offer equipment modules to trainee medics during their basic training, so they could operate equipment on graduation. However, the students and tutors consistently felt they had nothing to learn about technology and sidelined such modules, even though the clinical engineering department was constantly called to support operators who persistently misused their equipment.[202]

Resistance to such an idea must be overcome, for example the Botswanan NHI argued that there was insufficient space in the curricula and too many different types of equipment. However, a good initiative was undertaken from 1991 – 1994 when the Government of Zambia and FINNIDA undertook an Education Sector Support Programme. They revised and improved the curricula for health personnel, and re-equipped the Paramedical Studies Unit so that students would be trained on the equipment models they encounter on graduation (*Temple-Bird*).[200]

7.2.2 In-Service Training

Training is an on-going process. In order to retain staff skills, develop new ones, and counteract rapid staff turnover, it is necessary to have a regular programme of refresher courses. When basic training is inadequate, it is even more important for health service providers to make up the shortfall through comprehensive in-service training programmes. Such programmes are one important aspect of developing learning organizations as they can promote organizational procedures, communication, and institutional memory (Section 6.2).

All three countries had similar experiences, highlighting the problem of on-going skills-development. In Namibia, some staff were trained to use equipment at the time of commissioning either by the Chief Equipment Technologist (CET) from Windhoek or by suppliers, however not always the right type of staff or sufficient numbers attended the training. In-service training on equipment use was given to staff regularly only in certain areas (eg. the Intensive Care Unit at WCH). In Zambia little formal in-service training was organized, nor use made of training by manufacturers since so few companies were active in the country. The situation was similar in Botswana. Many departments depended on long-serving members of staff to pass on equipment skills to newcomers, but high turnover of staff (and the policy of six-monthly rotation of nurses) made it very difficult for departments to retain equipment skills. The MOH's Continuing Education Department was responsible for in-service training, but only had one member of staff, no national infrastructure for delivering an in-service training programme, and no funds or resources to enable maintenance staff to visit facilities and train staff. The wide-ranging equipment-related training needs identified by staff when interviewed were staggering; whilst some cadres such as radiographers or laboratory staff named specific safety or test techniques crucial to their work, many cadres (anaesthetists, maternity/labour staff) felt ill-equipped to operate all categories of equipment vital for their jobs, or to clean and care for them.

Health service providers need a structured in-service training programme to cover equipment issues. Since medical equipment is specific to health service providers alone, they often have to develop their own in-service training capacity to cover all equipment-related skills. Pre-requisites will be:

* agreement on the organizational procedures for the HTP system;
* development of training modules by maintainers and/or senior users, with assistance from manufacturers if necessary;
* organization of training schedules;
* provision of training seminars by maintainers, senior users, or manufacturers' representatives;
* travel and subsistence for staff attending seminars;
* an on-going training timetable catering for loss of staff and renewal of skills.

Since the case studies were conducted, there have been a number of small initiatives introduced in the three countries. Some Botswanan hospitals have introduced in-service training days (a day each week when staff gather to learn about a new procedure).[177] During the 1990s the clinical engineering unit at UTH in Zambia received support from the United States Agency for International Development (USAID) to develop a training unit. This enabled the maintenance staff to run a series of equipment-related training courses for operators (especially nurses working in specialty areas). Maintainers also train special equipment operatives who are responsible for specific machines. For example, the Head of Medicine nominated staff to be trained to set-up, operate, and take care of ECG recorders and run ECG recording sessions.[171]

The Department for International Development of the UK government (DFID) provided funding (1995 – 2000) for equipment and management skills-development at three central referral hospitals in Zambia. This prompted the development of policies for equipment training at induction (when staff first arrive in post), at commissioning (when new equipment arrives), to refresh (up-date skills), and to transfer these skills to staff not present at initial training sessions (*Temple-Bird et al*).[184]

7.3 OTHER PERSONNEL WITH EQUIPMENT RESPONSIBILITIES

To strengthen technical management capacity and organizational learning, it is necessary to raise awareness of equipment issues and increase equipment-related skills throughout the health service. Thus other types of personnel are needed with skills associated with the management of equipment. They require training in: selection, specification writing, tender adjudication, and procurement (to ensure the acquisition of suitable technologies); and stock control, planning, budgeting, administration, safety, workshop management, etc.

In all three case study countries, there was a shortage or lack of safety inspectors (for boilers, electricity, radiation protection, buildings, laboratory quality control, and infection control). The result can be seen in the poor level of awareness of equipment safety issues and associated support structures (Section 5.2.6).

Zambia and Namibia were short of purchasing officers, tender adjudicators, and stores personnel per se. Due to the institutional organization constraints explained in Section 6.1.2, purchasing and stores personnel in Botswana were trained as generalists. Thus in all three countries the staff available lacked an understanding of technological issues. Subsequently, there have been a number of initiatives to improve their understanding, and limit arbitrary purchasing. For example, the Botswanan Central Medical Stores developed a catalogue of medical supplies, instruments, small equipment, consumables and accessories, with illustrations to ease identification.[203] The Zambian-DFID hospital project developed a "Technical and Environmental Information for Suppliers" leaflet, and a 'tender evaluation information sheet'; these enable suppliers to offer suitable products, and tender adjudicators to select appropriate bids.[184] In Namibia, once suitable sources are found through tenders, the MOHSS gives companies two-year contracts to supply the agreed product nationally whenever a facility places an order; this ensures that facilities know the correct source of equipment and all receive the same item.[204-206]

Although there were posts such as hospital administrator, medical superintendent, and regional manager, none of the countries had developed a course in health administration, and all were short of such staff. There had been only limited technical assistance, management consultancies, and short training courses for this field. Although the MOH in Zimbabwe had, with DFID support in 1985, designed and established a 18-month diploma course in health service administration, none of the countries used this initiative either as a source of training or as a model for establishing their own course.[207] With a shortage of managers in general, it is proving difficult to introduce equipment management activities.

7.4 SHORTAGE OF MAINTAINERS AND EMPLOYMENT CONSTRAINTS

7.4.1 Numbers and Types of Maintainers

Maintenance requires a broad spectrum of technical personnel. Simple equipment can be maintained by personnel with basic skills, and most work accomplished by a team of artisans and technicians employed by the public sector. It may be possible to utilize private sector firms with the requisite skills, such as metal workshops and electrical companies. Equipment of medium complexity requires attention from skilled technicians, and sometimes health service personnel can be trained to undertake the work. Alternatively, local private firms may already have skilled technicians, such as representatives of international manufacturers, and independent firms. Sophisticated equipment usually has to be maintained by the manufacturer. It is difficult to train a local engineer to the same level as an employee of the manufacturer, and the cost is high if there are only a few sophisticated items to maintain. Maintenance management skills are required, including monitoring the quality and price of contracts with the private sector.

TABLE 7.2: Types of Technical Staff Available in General in the Three Countries Studied

WHO Definition	*Type A*	*Type B*	*Type C*
For medical equipment:	require electrical and/or mechanical craft skills and a broad understanding of common electro-medical equipment.	require additional technical, supervisory, and planning skills.	are managers with an engineering or technical background.
For all other technology areas such as plant, service installations, buildings, vehicles, office equipment, furniture, etc:	ditto - for skills in areas such as carpentry, plumbing, bricklaying, electrical installations, mechanics, refrigeration, and automotive work.	ditto	ditto
Zambia 1990			
Nationally recognized names:	*Artisan of various grades, Craft Certificate holder.*	*Technician, Senior Technician, Chief Technician.*	*Engineer, Engineer Manager.*
Availability:	Available in mines, industry, etc. MOH: a few; UTH (parastatal): several posts but 50% vacancies; MOW: several but being disbanded and MOH trying to reabsorb.	Available in mines, industry, airforce, etc. Private equipment maintenance sector mainly one-man concerns. MOH: several with poor skill levels; UTH: many posts but only 3 filled.	Available in mines, industry, and airforce, etc. MOH: None; UTH 1.
Botswana 1992			
Nationally recognized names:	*Artisans of various grades (industrial class staff), Technical Assistant.*	*Technical Officer, Senior Technical Officer, Chief Technical Officer, Engineer without management training.*	*Engineer, Senior Engineer, Chief Engineer - all with management training.* (Courses for engineers only introduced in 1990).
Availability:	Large numbers employed by govt., but being attracted away to the private sector, especially the burgeoning building industry. MOH had several, called '*plant operators*'.	Govt. mainly employed different grades of technical officer. A shortage nationally, with most going to the private sector.	Govt. depts had few engineers, and few had management training. Available in private sector, but must be trained abroad or are expatriates.
Namibia 1997			
Nationally recognized names:	*Workhands with very basic multi-disciplinary skills, Handyman for low and medium technology tasks, Artisans of various grades.*	*Multi-disciplinary Artisan, Technician, Specialized Technician, Engineering Technician of various grades.*	*Engineer, Technical Manager* (An engineering course had just started but had no graduates yet).
Availability:	Available in private sector. MOW: short of staff. MOHSS: very short of all staff	Nationals and expatriates used in private sector. MOW: short of staff, higher skilled staff based in capital only. MOHSS: very short of all staff	Available in private sector, but all engineers must be trained abroad or are expatriates. MOW: few, based in capital only. MOHSS: None.

Due to differing terminology globally, the *WHO* broadly describes the technical staff required in three categories: A, B, and C.[2] Although the descriptions seem to distinguish staff by skills, WHO stresses that within each type there is a wide progression of skills. One person may spend their career progressing to the highest level of achievement as one type, whilst another may attain additional skills and progress from type to type. WHO's full description of the three categories is briefly summarized in Table 7.2, with the situation in the three countries studied. Different labels were used in each country for technical staff, usually derived from names used by industry and major government technical employers (eg. the Ministry of Works). Artisans (Type A staff) of all disciplines were widely available in industry, were the most common type of government technical employee, but were being lost to the private sector. There were smaller numbers of technicians (Type B staff) of various disciplines graduating from polytechnic diploma courses; they mainly worked in the private sector and government ministries suffered shortages. Engineers (Type C staff) were in short supply, as Zambia had the only engineering course at the time of the case studies.

TABLE 7.3: Staff in the national medical equipment maintenance system, Zambia 1990

Workshop[1]	Senior Med Eqt Technician	Med Eqt[2] Technician	Med Eqt Techn absent on training	Med Eqt[3] Technician Trainee	Med Eqt[4] Auxiliary Trainee	Staff from external sources	Govt Hosps to cover in Province[5]
Central national	1	6	1	-	-	-	*[6]
Lusaka province[7]	-	-	-	-	-	-	1[8]
Eastern province	-	-	-	-	-	-	4
Northern province	-	-	-	-	-	-	8
Copperbelt province	-	-	-	-	1	-	5
Western province	-	1	-	-	-	-	6
Central province	-	(1)[9]	-	1	1	-	5
Luapula province	-	1	-	-	-	-	2
Southern province	-	1	-	-	-	-	7
North-western prov.	-	1	-	-	-	-	4
UTH clin.eng dept.	1[10]	2[10]	-	3	-	2[11]	1

1. New provincial workshops were planned but incomplete; any provincial maintenance staff in post had to work without proper facilities, tools, test equipment, vehicles, spare parts, materials, or manuals.
2. These technicians had varying levels of qualifications, & all needed/were awaiting further training abroad.
3. Newly recruited staff with no biomedical experience, gaining on-the-job training until scholarships for courses abroad came available.
4. These staff were originally hired as theatre technicians, and had no maintenance training.
5. These numbers would increase if other types of hospitals (ie. mission facilities, or hospitals acting as district hospitals) were to fall under the jurisdiction of the workshops.
6. The Central National Workshop covered the 3 provinces without workshops; it was meant in addition to support all workshops nationally.
7. As the Central National Workshop was in Lusaka province, perhaps a separate provincial workshop would not be established.
8. The University Teaching Hospital (UTH) was also in Lusaka province, but it had a workshop of its own with 5 technicians and helpers.
9. It was uncertain if this technician was still available for work.
10. These staff were seconded to the UTH Management Board from the Ministry of Health.
11. One technician seconded from the Japanese International Cooperation Agency, one from GEC Ltd (Ndola) for x-ray maintenance.

The situation for MOH medical equipment maintenance teams was studied. Table 7.3 shows that Zambia had allocated a number of posts for the national medical equipment maintenance service, but had considerable vacancies and only 16 employees with no engineers. UTH, a separate parastatal, had six technicians and helpers of its own with temporary expatriate and private sector help. In Namibia no maintenance network existed but there were a few individual hospital workshops. Table 7.4 shows ten technical staff in post (with no engineers), and a mix of vacancies, trainees, expatriates, and ancillary workers (clerk, cleaner, labourer, etc). Around the country, there were junior staff for repair of hospital furniture, the cold chain, and basic plant maintenance. Table 7.5 shows that Botswana's national maintenance network of four workshops, had 31 staff in post, seven being trained, and 18 vacancies. However 11 of these were ancillary workers, and of the maintainers most (19) were artisans leaving only seven with assorted higher qualifications (including an engineer). Although expatriates were used, all three countries had problems with language incompatibility, short contracts, and no mechanism for transferring skills to local staff.

TABLE 7.4: Technical staff in MOHSS for medical equipment only, Namibia 1997

Personnel	Windhoek Hospital Complex (Khomas Reg[1])	Central Furniture Repair Unit (Khomas Reg[1])	Oshakati Regional Hospital (Oshana Reg[1])	Rundu Regional Hospital (Okavango[1])	EPI Cold Chain	4[1] other regions in NW	6[1] other regions
Chief Eng.Technician	1	-	1	1 VSO	-	-	-
Senior Eng Technician	1 (vacant)	-	-	-	-	-	-
Engineering technician	1 (vacant)	-	2 (1 vac,1 VSO)	-	-	-	-
Artisan	-	1	-	-	-	-	-
Chief Cold Chain Officer	-	-	-	-	1	-	-
Principal C.C. Officer	-	-	-	-	4	-	-
Senior Clerical Assistant	1	-	-	-	-	-	-
Senior Handyman	1	2	-	-	-	-	-
Handyman	1	-	2	2	-	-	-
Workhand	1	4	6[2] (1 vac,2 trg)	-	-	24[3]	-
Cleaner/support staff	2	-	-	-	-	-	-
Govt.Hospitals covered:-							
Locally	2	2	1	1	*[4]	12	17
By outreach	1+[5]	*[6]	1+[7]	3[8]			

1. 13 regions in total; 5 in the NW including Oshana; 2 in the NE including Okavango; 4 in the Centre including Khomas; 2 in the South.
2. Two of these workhands were allocated to the district hospital in this region (see point 3 below).
3. Two workhands per district were available in the 5 NW regions only (including Oshana Region covered by the Oshakati workshop).
4. Meant to cover the whole country.
5. Meant to cover hospitals in whole country (13 regions) by outreach.
6. Catered for the 2 hospitals in the Windhoek Hospital Complex, but did not undertake much national repair work
7. Sometimes assists with some of the other 12 hospitals in the remaining 4 NW regions
8. The Rundu staff use 2 mobile workshops for outreach.

TABLE 7.5: **Staff in the Medical Equipment and Maintenance Services (MEMS), Botswana 1992**

	Southern Regional Workshop at PMH		Northern Regional Workshop at NRH		Satellite Workshop at MH		Satellite Workshop at SH		Away Training	Total		
Position	In Post	Vacant	In Post	Vacant	In Post	Vacant	In Post	Vacant		In Post	Vacant	Trg
MAINTAINERS												
(a) P&P Staff – Maintenance												
SHE	1									1		
HE				(1)							(1)	
CTO	1		1							2		
STO		(1)		(1)							(2)	
TO	1	(2)	1[1,2]	(1)	1	(1)		(1)	1	3	(5)	1
STA				(1)							(1)	
TA (SAA)		(1)	1						4	1	(1)	4
TA		(1)							2		(1)	2
Total of P&P Maint.	3	(5)	3	(4)	1	(1)		(1)	7[3]	7	(11)	7
(b) Industrial Class Staff Maintenance												
Carpenter	2					(1)		(1)		2	(2)	
Welder		(1)									(1)	
Plant Op.	6		2		1		1			10		
Total of IC Maint.	8	(1)	2		1	(1)	1	(1)		12	(3)	
(a) + (b): OVERALL TOTAL OF MAINT'ERS	11	(6)	5	(4)	2	(2)	1	(2)	7[3]	19	(14)	7
ANCILLARY STAFF												
(c) P&P Staff – Administration												
AAO	1									1		
Total of P&P Admin.	1									1		
(b) Industrial Class Staff – Ancilliary												
Labourer	1	(1)			1	(1)				2	(4)	
Driver	2									2		
Storekeeper	1				1		1	1		3		
Cleaner	1				1		1	1		3		
Messenger	1									1		
Total of IC Aux.	6	(1)			3	(1)	2	(2)		11	(4)	
(a) + (b) + (c) + (d): OVERALL TOTAL OF STAFF	18	(7)	5	(4)	5	(3)	3	(4)	7[3]	31	(18)	7

Note:

[1] Expatriate; [2] Leaving in 1993; [3] One member of staff was training in the UK, two members of staff were training in Canada, four members of staff were training at Botswana Polytechnic, some were due back from training in 1993, the rest in 1994.

Key SHE: senior hospital engineer; HE: hospital engineer; CTO: chief technical officer; STO: senior technical officer; TO: technical officer; STA: senior technical assistant; SAA: senior administrative assistant; TA: technical assistant; Plant Op: plant operator; AAO: assistant administrative officer

All the countries had too few technical staff. But in Botswana and Namibia, the MOH had recognized that future workload would require staff numbers to increase to cover:-

* improvements in maintenance provision to increase equipment life-time;
* hospital upgrades;
* introduction of newer electronic technology;
* increased planned preventive maintenance (PPM);
* expansion of technical staff into more facilities/districts;
* introduction of new services (such as radiotherapy);
* improvements in user training and safety monitoring;
* taking on first-line maintenance responsibility for plant;
* reduction in future medico-legal liabilities;
* an increased management role.

For this, a vast expansion in numbers is required. By 2000, Zambia still had no national equipment maintenance service, but individual semi-autonomous hospitals were trying to hire staff, and with the closure of many mine hospitals and the national airline some technicians and engineers were available.[171] In Botswana, MEMS had calculated its projected needs for permanent and pensionable (P&P) staff, but these targets were not fully reflected in the next national development plan.[208] Thus their target of 10 hospital engineers, 37 technical officers, and 37 technical assistants of various grades were not attained by 2000.

Similarly, the Namibian MOHSS calculated an establishment plan for introducing a national equipment management structure through a network of workshops countrywide. They found they needed: one clinical engineer, 13 engineering technicians, 11 artisans, 75 handymen, 9 workhands, 7 clerks, and 5 cold chain officers (*MOHSS & Temple-Bird)*.[209] There were considerable constraints to finding, hiring, training, and retaining such large numbers of cadres, as detailed in the rest of this Chapter. This hindered the development of technical management capacities in the organizations concerned.

7.4.2 Employment Conditions

The World Bank reported that the shortage of staff can be traced in part to compensation problems, especially in the public sector. Wages and salaries tend to be so low that morale and motivation are affected adversely. In a study of 15 African countries civil service salaries declined substantially, by as much as 50%, from 1975 to 1985.[191] By 2000, the *WHO* was still reporting that inadequate pay and benefits, together with poor working conditions, are the most pressing problems facing the healthcare workforce in less developed countries.[21]

In the Zambian public sector (1990), an healthcare technology maintenance technician only received around US$ 515 (18,000 Kwacha) per annum and a chief technician US$ 686 (K24,000)[p]. This was not enough to live on, and with electrical components (such as circuit breakers) selling for K500 on the black-market many health facilities faced serious problems of stolen items. MOH staff believed that the high loss of maintenance staff to the private and parastatal sectors was due to vastly increased salaries there. Although salaries in the private sector for equipment maintenance work were less than speculated, being only 25% higher than the public sector, staff could receive substantial perks such as virtually rent-free accommodation, use of company vehicles, and sometimes free medical care. However in the private sector, personnel were expected to work longer, more strictly controlled hours, with greater supervision and higher output targets. Some staff were not attracted to this sort of regime.

The Namibian MOHSS reported (in 1997) finding it difficult to attract and retain maintenance staff as public sector salaries were not competitive; mid-scale salaries ranged from US$ 11,000 (N$50,000)[q] p.a. for graduate engineering technicians to US$ 17,500 for chief engineering technicians.[210] Although there were employable workhands and handymen in the north-east of the country on salaries of US$ 2,200 and US$ 5,500 p.a. respectively, the MOHSS could not hire them as they had no accommodation to offer.

In Botswana (1992) the bottom end of the private sector pay scales for technical grades began at a level 27 – 36% higher than the top of the public sector pay scales for the same qualification and experience. In the private sector, technical officers earned p.a. US$ 14,300 – 17,200 (30,000 – 36,000 Pula)[r] and engineers earned US$ 20,000 – 23,000 which was 63 – 66% and 45 – 55% respectively more than their public sector counterparts who received US$ 8,600 – 10,400 and US$ 13,000 – 15,700, even though the public sector cadres had recently received a pay increase. In the public sector, these scales were only for permanent and pensionable staff (all technicians and engineers), and not for the majority 'industrial class' staff (artisans) who were paid on daily rates.[71] An institutional organization constraint was that the MOH managed their maintenance staff in two different ways: P&P staff fell under the Manpower division, and 'industrial class' staff fell under the Health Administration division. This meant that different types of maintenance staff on the same MEMS team were treated differently, and confusion reigned about which division should be in charge (Section 6.1.2).

p. In 1990, US$ 1 = 35 Kwacha
q. In 1997, US$ 1 = 4.56 Namibian dollars.
r. In 1992, US$ 1 = 2.1 Pula.

When recruiting expatriates, the Botswanan MOH tried to recruit general all-rounders believing that specialization was a luxury they could not afford. However, technical personnel available on the international market with sufficient qualifications and experience usually have specialized in a particular area (eg. x-ray equipment, laboratory equipment, monitoring equipment). Thus MOH officials reported great difficulties in finding the sort of person they thought they needed.

If suitable technical staff could be recruited, a major institutional organization constraint to hiring them was the lack of establishment posts. The Public Service Commissions (PSC) of the case study countries had complex regulations determining the pay scales for different categories of public sector staff. Entry qualifications, salary scales, and career progression are dependent on your designated 'label'. Thus, it is important for staff to be correctly classified. MOH maintenance staff were a new cadre and any national maintenance networks were fledgling structures (Section 6.1). Thus maintenance staff were held against posts for other (usually lower paid) cadres, were invisible in the MOH staff establishment, paid the (lower) salary associated with the post, and deprived of opportunities for career progression. Engineers, technicians, and artisans have different labels depending on who employs them, and it was unclear to the PSC how MOH 'hospital' or 'clinical' engineers, for example, related to other public sector engineers.

Maintenance staff require specific training during their careers to reach the PSC classification of entry points to posts. Thus two major problems faced them – the difficulty of certifying their skills, and job descriptions which place too much emphasis on paper qualifications. For example in Botswana, although many Type A staff left school a long time ago, had many years of experience, and learnt their trade on-the-job, they did not have certificates that the PSC recognized.

The Namibian MOHSS began work in 1998 on developing establishment posts for the introduction of a new National Equipment Management Structure.[209] Some planners proposed that this required reallocation of posts from other cadres (medical and paramedical). They saw the pointlessness of financing a large medical salary bill when the tools of the trade (the equipment) were not functioning, and proposed a better balance between these two needs in the MOHSS budget (see Section 8.5).

In all three countries, once technical staff were in post, they lacked adequate conditions of service, such as reimbursement for travel and subsistence, night shifts, protective clothing, use of personal tools, etc. To build a technical management capacity, initiatives are also required to retain staff and maintain their morale; but Human Resource Development (HRD) initiatives such as open staff appraisals, personal goal-setting, feedback on performance, training for career progression, etc. were not in place (see Section 7.6).

Another missing area is technical support and advice by contemporaries through a professional body (*Yadin*).[211] There are international bodies to which countries can affiliate, such as the International Federation for Medical and Biological Engineering and the International Federation of Hospital Engineering. But it wasn't until 1994 that an African body was established which individuals could join – the African Federation for Technology in Healthcare (AFTH). The ministries of health in Botswana and Namibia have supported their technical staff attending AFTH conferences, but Zambia has been slower to fund access.

7.5 TRAINING OF MAINTAINERS

Technical training for healthcare technology maintenance personnel is complex due to the range of equipment involved, and its application. For much basic equipment, knowledge is required both of electrical and mechanical processes together with workshop and repair skills.

For more sophisticated equipment, knowledge of electronics, microprocessors, automation, and control theory is required. Modern medical equipment also requires an understanding of and practical experience in fields such as (radiation) physics, physiology, and clinical measurement. Technical staff need to understand the application and principle of operation for each piece of equipment – only then will they be able to maintain it correctly and safely. Safety is an extremely important issue, since much medical equipment connects directly onto patients, maintenance staff cannot simply walk into sterile areas such as operating theatres and start work, and many types of equipment can be hazardous. Also, technical staff require equipment management skills. As the *WHO Inter-regional Meeting on Manpower Development and Training* recommended, maintenance personnel in the health sector will require a series of training periods throughout their careers in order to obtain these wide-ranging skills.[84]

It is difficult to hire technical staff who already have clinical skills. Therefore ministries of health have to consider the advantages of the different options available to them: hiring school-leavers or basic-level technical graduates and training them on-the-job; hiring higher-level graduates and offering them in-service training opportunities to increase their skills; hiring and bonding staff then sending them abroad for specialized training; and taking clinical staff with a technical aptitude and turning them into technicians. Any on-the-job and in-service training requires a training infrastructure within the MOH and recognition of training to enable staff to progress through their careers (Section 7.4.2).

When studying African industrialization, *Mytelka* reported that everywhere in Africa during the transition-to-independence years, both state and missionary schools tended to provide a classical education emphasizing basic administrative and literacy skills rather than training the skilled labour, engineers, chemists, managers, and accountants needed by industry. This pattern, supplemented by training in pure sciences, persisted well into the post-independence era and contributed to the lack of integration between what can be called the knowledge production and the goods production sectors. She stated that by 1989, one would still be hard put to find universities in SSA offering majors in such fields as textile or petroleum engineering, and the training of skilled workers and line supervisors through post-primary vocational schools or apprenticeship programs remained seriously deficient.[143] By contrast *Prokopenko* reports that the prime reason for Japan's industrial success has been its HRD system – a unique combination of school education, vocational training, post-employment education, and on- and off-the-job training and career development conducted by Japanese companies, which distinguishes itself in teaching effective learning habits and maintaining an effective learning environment.[212]

7.5.1 Artisans

All three countries ran a system of trade-testing, common world-wide, to enhance the use of apprenticeships in industry, provide artisans with structured in-service training, ensure artisans develop standard recognizable trade skills, and take a series of nationally recognized trade tests. In this way artisans (tradespeople) can progress in their careers, and gain promotion with guaranteed salaries across the industrial sector. Training and trade-testing of artisans usually falls under a national body, such as the National Advisory Board for Apprenticeship and Industrial Training (NABAIT) in Botswana, with a central Training and Testing Centre offering advice on training and trade-testing standards for various trades, such as the Madirelo Training and Testing Centre (MTTC) in Gaborone. A mix of employer on-the-job training and short fixed courses at Vocational Training Centres (VTCs) around a country provide artisans with the training, and the Training and Testing Centre then tests them. If the artisan progresses through all levels, s/he will attain some form of national Craft Certificate.[213,214]

The quickest route to a trade test is for artisans with secondary schooling, but those with lower qualifications can still work towards trade tests over a longer period. The research in Botswana enabled me to identify and present the different possible routes, as shown in Table 7.6. This system works well for plant maintainers (plumbers, carpenters, builders, etc.), but has in-built constraints for craftspeople (artisans and below) working as medical equipment maintainers. First, none of the apprenticeable trades are aimed at the mixed skills required for medical equipment maintenance. Typical relevant apprenticeable trades are: installation and appliance electrician, fitter and machinist, welder and fabricator, refrigeration and air-conditioning mechanic, and radio and TV repair.[213] Some of these skills are similar or would be useful if bits of different trades could be selected. But to be eligible

TABLE 7.6: Training routes for obtaining a National Craft Certificate trade test (Botswana '92)

Route	A	B	C	D
Entry Requirement	Below standard VII[1]	Std VII	JC[1]	JC
Training Method	On-the-job training	Training course mixed with work	Full-time training course	On-the-job training on Apprenticeship scheme
Training Body	Employer provides inservice training developed with NABAIT[2]	Such as Brigades training	VTC, ATTS, or Botswana Polytechnic	Employer in an apprenticeable trade registered with NABAIT[2]
1st period of training	3 years of work/training + 13 weeks[3] total of IT[4] at registered places[5]	3 years of work/training + 13 weeks[3] p.a. of IT[4] at registered places[5]	1 year of training + 13 weeks[3] total of IT[4] at registered places[5]	1 year of training + 13 weeks[3] total of IT[4] at registered places[5]
Test	1st assessment test at MTTC	1st assessment test at MTTC	1st assessment test at MTTC	1st assessment test at MTTC
Qualification	**Trade Test C-level**	**Trade Test C-level**	**Trade Test C-level**	**Trade Test C-level**
2nd period of training	2 years of work/training + 13 weeks[3] total of IT[4] at registered places[5]	2 years of work/training + 13 weeks[3] p.a. of IT[4] at registered places[5]	1 year of training + 13 weeks[3] total of IT[4] at registered places[5]	1 year of training + 13 weeks[3] total of IT[4] at registered places[5]
Test	2nd assessment test at MTTC	2nd assessment test at MTTC	2nd assessment test at MTTC	2nd assessment test at MTTC
Qualification	**Trade Test B-Level**	**Trade Test B-Level** Must join an employer for last stage → D	**Trade Test B-Level** Must join an employer for last stage → D	**Trade Test B-Level**
3rd period of training	3 years of work/training + 13 weeks[3] total of IT[4] at registered places[5]			2 years of training +13 weeks p.a.of IT[4] at registered places[5]
Test	Final Assessment			Final Assessment
Final Qualification	**National Craft Certificate**			**National Craft Certificate**

Notes:

1 Pupils take 7 years of primary school finishing in Standard 7 with the Primary School Leaving Certificate (PSLC), then 2 years of junior secondary finishing with the Junior Certificate (JC).

2 NABAIT = National Advisory Board for Apprenticeship and Industrial Training.

3 The 13 weeks of IT may be in one block or may be split into blocks of 6 or 7 weeks each year.

4 IT = Institutional Training specified by NABAIT and MTTC and is skill's related theory in the following subjects: trade theory; skill's related mathematics and science; trade related technical drawing; associated subjects both technical and commercial; English; civics.

5 Places registered to offer IT are: Madirelo Training and Testing Centre (MTTC) & Automotive Trades Testing School (ATTS), Gaborone; Vocational Training Centres in Selebi-Phikwe, Maun, Palapye and Jwaneng; & Botswana Polytechnic in Gaborone.

for trade-testing, an artisan must have recorded proof of three-years work in that trade. To progress, subsequent trade tests must be in the same trade with registered proof of continued work in that trade. But if MOH craftspeople do welding, for example, they cannot say their work consists solely of welding and fabricating, and are not able to register for that trade. The second problem is that artisans are required to attend periods of Institutional Training (IT) at the VTCs. There was a shortage of training places and a shortage of MTTC staff, thus in 1992 there was a two to three year wait for training and testing. Therefore MEMS' artisans with years of experience and good practical skills had not obtained trade test certificates.

In response, the ministries of health undertook in-house training instead. For example, handymen hired by the MOHSS in Namibia were given limited training to orient them to medical equipment work, but this was not formalized or recognised. In Botswana, although MEMS and the Department of Supply workshops maintained instrumentation, none of the trade-testing courses suited their employees. So they developed their own courses and ran them for many years, but could not get recognition either from the MTTC (as the required IT content was absent) or the PSC. Thus these courses did not aid the career progression of artisans and staff could not be promoted within their 'industrial class' grading, or move onto the first step of the P&P scales ie. into technical assistant posts (Section 7.4.2). This was an especially important issue because the MOH planned to place their experienced Type A staff as first-line maintenance staff at district hospitals, once they were promoted. Instead people with marketable skills were blocked, frustrated, and in danger of leaving the public sector. This hinders any attempts to retain a technical capacity within the health service organizations, and reduces the number of necessary technical information 'gatekeepers' available (Section 6.2.2)

A strategy is required to enable certification of medical equipment artisans and thus their promotion; new apprenticeable trades and new trade testing courses need to be created. During the Botswana study, I held discussions with the MTTC and the Technical Education Department of the Ministry of Education to see how this could be achieved, which could prove an important initiative for other countries. They were willing to work with the MOH to develop and register its in-service training facilities, and establish a trade testing programme for MEMS staff. The following steps were required:

* MOH and MTTC would liaise on the requirements of NABAIT;
* MOH would define for MTTC the trade to be tested, background of the artisans, skills to be acquired, sort of work they undertake etc;
* MEMS, MTTC, and VTC, would develop curricula, identify trainers, and establish adequate facilities for training activities;
* MTTC would approve the MEMS training resources, and qualifications of trainers (VTC may even supply trainers);

* MEMS would run on-the-job training courses;
* MTTC would undertake trade tests at the MEMS workshop and issue certificates.

Unfortunately, by 2000 the MOH in Botswana had still not pursued this initiative.[177]

7.5.2 Technicians

All three countries had a system of City & Guilds (C&G)-certificate and Diploma-level technical training courses, common to English-speaking countries. Polytechnics and Technical Colleges in each country offered courses for various engineering disciplines. They produced suitably skilled graduates for the plant and service installation maintenance organisations to recruit, such as electricians, mechanics, refrigeration & air-conditioning technicians, etc. But they did not provide the range of mixed technical skills required by medical equipment maintainers, or modules in biomedical subjects and applications necessary for their work.

Botswana Polytechnic courses were not suited to MOH employees who were trained whilst in post. For example, certificate courses for electrical engineering technicians did not introduce electronics until Part 3, industrial measurement and control did not introduce instrumentation until Year 3, industrial electronics did not run every year, telecommunication offered its microprocessor option only every two years.[215] It was common for MOH officials not to be conversant with the content or the range of courses available. Maintenance personnel need to increase their skills throughout their careers, and the technical training structure requires them to attend a series of courses during their working life. Table 7.7 presents the different routes that were routinely possible that the research in Botswana enabled me to identify, as a typical example. However, none of these courses would provide graduates with any knowledge of medical equipment.

With numbers of medical equipment maintenance staff so low and expected to rise slowly in the three countries studied, the Polytechnics would find it difficult to develop a course specifically for the MOH as the likely throughput of students per year would not make it viable or worth recruiting specialist lecturers. However, alternative modular approaches were possible (see Section 7.5.4) , but by 2000 such possibilities had still not been pursued.[177]

Students need training appropriate to their employment. Since entry-level technicians had no medical equipment maintenance experience, health service maintainers had to provide training on-the-job for new staff. In Botswana, the mission organization AMMB had started on-the-job training (Section 6.1.2) and MOH ran on-the-job training for many years. But like artisan training (Section 7.5.1), it was not formalized, and there was no set

TABLE 7.7: Training routes for obtaining C&G Certificates, Diplomas, & Degrees (Botswana '92)[1]

Route	E	F	G	H	I	J
Entry Requirement	**COSC[2]**	**COSC or Craft[3] Certificate**	**COSC[4]**	**COSC**	**A-Level or C&G Part II Certificate**	**Ordinary Technician Diploma**
Training Method	Training part-time whilst employed[5]	Training full-time with periods of industrial attachment	Full-time training course	Training full-time with periods of industrial attachment	Training full-time with periods of industrial attachment	Training full-time with periods of industrial attachment
Training Body	Botswana Polytechnic	Botswana Polytechnic	Botswana Polytechnic	University and Polytechnic of Botswana	Botswana Polytechnic	Botswana Polytechnic
1st Period of training	1 day per week for 1 year	1 year full-time	2 years full-time	6 months full-time on UB/PESC[6]	6 months full-time on BP/EFC[7]	1 year full-time
Test and Qualification	**Exam for Certificate in Industrical Electronics[8]**	**Exam for[9] C&G Part I Certificate**	**Exam for Ordinary Technician Diploma[10]**	**Exam for Pre-Entry Science credits**	**Exam for Engineering Foundation credits**	**Exam for Part 2**
2nd period of training/work		1 year industrial attachment		1 year full-time on UB/BSc[11]	1 year full-time	6 months industrial training
Test and Qualification				**Exam for BSc Year 1 credits**	**Exam for Part 2**	
3rd period of training/work		1 year full-time		6 months full-time on BP/EFC[7]	6 months industrial training	1 year full-time
Test and Qualification		**Exam for[9] C&G Part II Certificate**		**Exam for Eng Foundation credits**		**Exam for Part 3**
4th period of training/work		1 year industrial attachment		1 year full-time	1 year full-time	6 months industrial training
Test and Qualification				**Exam for Part 2**	**Exam for Part 3**	
5th period of training/work		1 year full-time		6 months industrial training	6 months industrial training	1 year full-time
Test and Qualification		**Exam for[9] C&G Part III Certificate**				**Exam for BEng Degree[12]**
6th period of training/work				1 year full-time	1 year full-time	
Test and Qualification				**Exam for Part 3**	**Exam for BEng degree**	
7th period of work				6 months industrial training		
8th period of training				1 year full-time		
Test and Qualification				**Exam for BEng Degree[12]**		

Notes:

1 Only courses which may suit MEMS staff are shown
2 After JC, pupils take 3 years of senior secondary finishing with Cambridge Overseas School Certificate (COSC) = O-Level
3 236 Craft Certificate
4 The student must reach division 1 or 2 in COSC
5 Students must be employed in a relevant industry
6 University of Botswana Pre-Entry Science Course
7 Botswana Polytechnic Engineering Foundation Course
8 This course is not run every year
9 City & Guilds Certificate courses available:-
C&G 803: Electrical Engineering Technician
C&G 271: Telecommunication Technician
C&G 275: Industrial Measurement & Control
10 Ordinary Technician Diploma in Mechanical & Electrical Engineering (C&G 800-1)
11 1st year of University of Botswana BSc Degree
12 Degree in Electrical and Electronics Engineering

curriculum or training plan. Namibia and Zambia had not started any in-service training initiatives to improve maintenance skills. Thus ministries of health were hiring basic graduates who then queue for training opportunities overseas, whilst trying to function in their post (Section 7.5.4).

By contrast, Zambia Consolidated Copper Mines (in 1990) ran plant maintenance courses nationwide in subjects like refrigeration and air-conditioning, and their Kitwe School trained mine technicians in instrumentation subjects including modules for different types of medical equipment found in mine hospitals. This school had recently developed a longer (36 week) training course that had been approved by the Zambian Department of Technical Education and Vocational Training. Unfortunately no other health service providers made use of it[s].

7.5.3 Engineers and Technical Managers

The University of Zambia ran engineering degree courses, but in 1990 the graduates mainly went to the private sector, national airline, or abroad to work. Namibia used institutes abroad to train engineers and engineering managers; but in 1997 the Polytechnic started a new engineering course. In Botswana, engineering courses were introduced in 1990 at the Polytechnic, but were only in limited subjects (electrical and mechanical), did not run every year, offered no management training, and had not produced graduates by 1992. Also, RCM Consultants Ltd and the Institute of Development Management in Gaborone ran a range of seminars covering aspects of maintenance management. MEMS' senior technicians would have benefited from these courses if the MOH had allocated funds for them to attend.

7.5.4 Training Abroad

Training for medical equipment maintenance is available abroad in the public and private sectors, but regional courses are limited. The research enabled me to compile the various courses available in or planned for the region, as shown in Table 7.8; these allow medical equipment technicians to progress through their careers, although some suffer from occasional closure or changing aims. The MOH in Namibia had only sent one person for higher-level training in Canada and the UK. It was rare for these courses to include equipment management subjects. Thus the course I helped to establish and taught on specifically developed such modules, prompted by my experience and research in developing countries.[202,216]

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s. Unfortunately as the economic crisis deepened over the following 5 years, ZCCM closed the Instrumentation Training School.

TABLE 7.8: **Training courses in medical equipment maintenance available for the region**

Type of Course	Entry Requirement	Exit Qualification	Region Covered	Training Institute	Comments
Craftsperson Basic craft course	6 yrs primary school	Craft certificate	National	National programme	MOH informal in-house training
Polyvalent Technician					
Basic Technician course	2-3 years secondary school or experience	Certificate - C&G equivalent	National	National	Most countries do not have enough students to support a specific course
Proposed 18 month Polyvalent Technician course	O' Level or equivalent experience	Certificate - C&G equivalent	Regional	Swaziland College of Technology (SCOT)	Was in the planning stage in '94
Specialist Technician Training					
5 month specialist technical courses	6 years secondary school plus experience	Advanced Technician Certificate	Africa and Middle East	Higher Technical Institute, Cyprus	2 courses were available; Electro-medical & Clinical Lab eqt; Opthalmic & Dental eqt. But subsequently closed.
Advanced Technician Training					
Diploma	Certificate course or C&G Level 2	Diploma - C&G equivalent	Regional	SCOT	Had problems running each year
Diploma	Certificate course or C&G Level 2	Diploma - C&G equivalent	Regional	Pretoria Technikon	
Engineering Technician					
2 yr Biomedical Engineering Technician course	O' Level or equivalent experience	National Diploma	International	British Colombia Institute of Technology, Canada	
3 yr Medical Engineering course	O' Level or equivalent experience	OND	Regional	Mombasa Polytechnic, Kenya	This is a national course opened in the mid-'90s to other nationals
Proposed 2 yr Medical Engineering Course	OND or equivalent	HND	Regional	Jointly by Kenya and Zimbabwe Polytechnics	Not available yet Plans: Medical electronics at Nairobi Poly, Imaging at Harare Poly
Higher Level					
Short Tailor-made courses			International	Glasgow	
1 yr Medical Electronics & Med Eqt Management course	HND or equivalent experience	PG Diploma Distinction equivalent to BSc	International	St.Bartholomew's Hosp. Medical College, London	End of '90s closed to move location
Other courses at other training institutes					

NOTE: This table shows the training institutes for African anglophone countries. There are other networks for Francophone Africa, and other parts of the world. The WHO regional basic technician course in Sierra Leone was closed in the '90s.

One regional initiative was the Diploma course established at Mombasa Polytechnic, Kenya through collaboration between the ministries of Education and Health, and GTZ.[217] With a large population, large number of health facilities, and a government plan for a national medical equipment maintenance network, Kenya was a model where the MOH could guarantee sufficient students (20 per year) to sustain a local course. Thus, the education authorities found it worthwhile to develop a new course that enabled the MOH to staff their planned maintenance service. The course later opened its doors to other English-speaking African students. GTZ supported a similar training course in Senegal for French-speaking Africans. It also supported a different kind of medical equipment maintenance training in El Salvador; this initiative combined elements of various local training possibilities to form a modular training programme.[217]

Countries use a system of sending staff in turn to the few available regional and international courses, however there are two common problems: i) many staff do not have the necessary entry qualifications – again certification of local training would help; and ii) not many scholarships can be obtained each year.

7.5.5 Manufacturers' Courses

Manufacturers of equipment usually offer training for both user and maintenance staff, run by themselves or their representatives. The training is either at their factory/office or on the client's site (at the hospital). However in developing countries the reality of having manufacturers' training is greatly reduced. Zambian MOH officials reported during interviews that they did not make use of manufacturers' courses; although UTH made more use of them in subsequent years.[171] MEMS officials informed me that, by 1992 most equipment users and maintainers in Botswana had not received training specifically from the equipment manufacturers.

During the Botswanan study the 29 equipment suppliers most commonly used by the MOH (local, regional, and international) were surveyed to identify the sort of training on offer (Section 3.3.2). Even though observers such as *Roberts et al* question the wisdom of sending developed-nation technology to developing countries without investing in local people, a significant minority offered no training at all.[216] A large proportion only arranged training courses if they were requested by the client, a further significant proportion (mainly local and regional firms) stated that training was available as standard practice however the MOH had never asked for it (see Section 9.3). By contrast Namibia had introduced an initiative whereby user training was automatically provided by the equipment suppliers (although only for high tech equipment), because the MOHSS had made this a tender condition.[205]

7.6 PERSONNEL MANAGEMENT FOR CAPACITY BUILDING

Prokopenko reminds us that there is a wider understanding of human resource development than education and skills-development, which includes the conditions of working life. HRD aims to achieve planned human-resource output in terms of productivity, quality, innovation, satisfaction and willingness to change, as well as personal growth. Its purpose is to develop people for life as well as work, to enable them to be self-sufficient, self-reliant and capable of contributing to society and to render them able not only to do their tasks, but to keep their jobs as well.[212] Thus if there is to be organizational learning for the HTP system (as well as individual learning), health workers must understand their place in the system and want to stay, work, and develop. The organizations need to offer incentives to achieve this – not necessarily personal advancement such as salary increases, but structural and procedural changes to improve performance. This Section looks at these motivating factors.

Staff need to develop a sense of responsibility towards the equipment they use and a feeling of ownership. In all three countries, it was reported that low morale and malaise led in some circumstances to little accountability for work done, or for tools and equipment handled (Section 7.1). The lack of an organized structure of MOH maintenance personnel placed around the country, or only a fledgling one, meant that staff were not answerable to superiors within a hierarchy. Exceptions to this in the public sector were the parastatal UTH in Zambia and the workshop network in Botswana; here the technical services departments appeared to have achieved some degree of supervision and support so that activities were being undertaken by staff independently and unprompted. This appeared to be due to the larger teams who worked together, the wider range of skills present, and a hierarchy containing managers.

Examples that worked well in the private sector were the mine hospitals (for company examples, see Section 9.5). Both the ZCCM hospitals in Zambia and Jwaneng Mine Hospital in Botswana had much better equipment statistics than the public sector (Section 5.1), and the analysis shows that this can be attributed to the technical management capacity and philosophy of the mine being transferred to the hospital, for example:

* the hospitals were linked to technically complex mines which could provide technical support, saw maintenance as a crucial service, and had a large resource of personnel to call upon;
* the ability to obtain, and pay for, spare parts and manufacturers' call-outs on site at short notice;
* the implementation of PPM and good maintenance record-keeping.

Pfeiff states that the motivation for professional commitment may be based on political, social, familial, or even religious or philosophical reasons, and recognition of achievement is often restricted to idealistic aspects. Experience shows that achievement and success at work are best rewarded by material incentives in the form of adequate pay. But this must be accompanied by social recognition in the form of comparative status to the other (hospital) staff. The lack of social recognition of technical qualifications is still widespread in the medical field and is an expression of uncertainty. With the exception of cultural and religious peculiarities, the staff structure in the healthcare facilities of developing countries is European-oriented and therefore hierarchical in nature.[103]

Zambia in 1990 was an extreme example of a centralized system, which had an old model for personnel relations where the boss was always right, staff were told what to do, and may even be discouraged from using initiative. To overcome a lack of self-motivation and a lack of pride, newer HRD strategies are required which make use of staff appraisal methods open to scrutiny. The process should be seen as a positive two-way negotiation of ways in which to improve performance, ie. what can the individual do, but also what can the manager do to make the working situation better.[218]

A good example I found in Botswana was the Kgalagadi Breweries which had a great deal of mechanical, electrical, and electronic equipment that had to be kept in working order both to sustain production and for safety reasons. They had motivated their staff to have a sense of personal responsibility thus ensuring that maintenance was undertaken as scheduled. How was the breweries achieving this when their counterparts in the public sector were generally failing to promote such commitment to duty? The Breweries had collaborated with local consultants (RCM Ltd) to introduce maintenance and personnel management. They put in place a fairly standard maintenance job record system including job cards, equipment service records, PPM schedules, etc. In addition they paid attention to staff motivation and productivity by introducing team working, and the following staff appraisal strategies:

* involve each member of staff in developing their own work goals;
* develop work plans which have to be adhered to;
* publicly display progress against targets so everyone is open about team and personal achievements, and can be congratulated or chided and encouraged;
* help individuals identify their problems and the constraints to better productivity;
* develop personal improvement strategies;
* provide feedback on progress, improvement, and response;
* offer training programmes;
* increase salaries and incentives;
* ultimately sack staff, if necessary.[71]

These strategies improved staff response to tasks enormously, and instilled an attitude in the staff of personal and collective pride in their work – generally absent in the public sector. Technology management literature provides comparable examples, for instance *Adler & Cole*, when studying the best organizational design to support learning (for auto plants), believed the success of companies was due to their commitment to treat employees as their most important assets and to provide opportunities for employee growth. In addition, great benefits were obtained from organizing staff in mixed-skilled and mixed-performance teams, thereby providing a mechanism for lifting the 'laggards'.[183] Other motivating initiatives are being tried elsewhere, such as Kenya, to alter government and treasury rules so that public sector maintainers can undertake private work and the income generated can be split between the individual and the development of the workshop (*Temple-Bird et al*).[219]

7.7 CONCLUSION

The acute shortage of technical management skills is common to many fields in developing countries, for example *Abdinaser* and *Prage* talk of the case of scientific instruments for schools, academia, and research.[220,221] The shortage in the health sector has been discussed for a long time – *Mitchell et al* complained about laboratory equipment in 1983, and *Benini* about nuclear and related medical equipment in 1988.[90,222] Capability constraints are a feature of being a developing country, but of interest is why this situation persists. Hence this Chapter begins the new theoretical perspective of the Thesis, and takes a *Development* approach. As *Forbes* reminds us, younger nations are expected to telescope into a few years economic, technical, and social development that took generations to accomplish in older developed nations. Such rapid industrial development requires both a high level of indigenous capability, and the effective use of that capability.[223] Thus the situation discussed in this Chapter introduces a major development issue.

Chapter 6 looked at several structural and procedural strategies for improving organizational learning. However, *Cohen & Levinthal* believe that an organization's absorptive capacity (Section 6.2.1) will also depend on the absorptive capacities of its individual members; and "the development of the organization's absorptive capacity is dependent on prior investment in the development of its constituent, individual absorptive capacities, and will build cumulatively".[179] *Pfeiff* proposes that at present it can be assumed that in health facilities of the Third World qualified technical staff are either lacking or inadequately integrated. He notes that this is the case, even though all the statements made regarding the need for technical competence when handling equipment would make the existence of technical staff appear to be an indispensable prerequisite for orderly, economic, and safe operation of technical equipment.[103] Thus this Chapter looks at the availability of equipment-related skills amongst clinical, technical, and other staff in the public health sectors of the three case study countries, and the organizational strategies taken to acquire and retain a national technical management capacity, such as effective career structures and human resource development.

All three countries suffered from skills' shortages relating to equipment use; one reason given was the shortage of staff. Other reasons are the lack of knowledge amongst users of the operation of equipment, care of equipment, and equipment management procedures. A crucial factor is that no modules on these subjects exist in the curricula for the basic training of nursing, paramedical, and support staff. Limited induction training was provided at facility level to transfer such skills to newly arrived staff, and the lack of training materials and manuals is well known.[224,225] Health service providers will need to pursue a combination of strategies to adequately develop equipment skills, such as liaising with training institutions to improve equipment training, and offering on-the-job and in-service training programmes. Such an investment will be well worthwhile, since *Halbwachs* states "users of medical equipment can be assumed to cause, either directly or indirectly, two out of every three equipment breakdowns".[198] Not all equipment skills were poor, and in some cases staff had developed different skills to those in developed nations due to the types of technology available; this is pursued further in Section 9.4.

All three countries were severely short of technical staff. One major stumbling block was the shortage of establishment posts in the MOH for the maintenance service; this effected potential salary scales, career progression, and public sector recognition for technical personnel. Without an adequate career structure to place staff in, it will remain very difficult to acquire and retain sufficient numbers of technical personnel to create a national equipment maintenance service. Countries may have to seriously consider altering the ratio of clinical to technical staff, so that clinical staff have functioning equipment to work with.

The technical staff that were available were short of maintenance skills, and lacked knowledge of equipment and maintenance management procedures. The ministries of health had limited in-house technical training capabilities, and poor access to external training opportunities. When discussing technological capabilities and industrialization, *Lall* points out that "whilst the precise nature of the benefits of vocational as opposed to general training, and pre-employment as opposed to post-employment training, is still subject to debate, it is indisputable that the speed of technical change in modern industry necessitates increasing inputs of training and retraining".[226] *Prokopenko* believes that vocational education and training (VET) can improve labour mobility, adaptability and productivity, and therefore linkages must be created between VET institutions and industry/employers with the latter even assisting with financing the former.[212] The research in Botswana enabled me to establish the training routes for artisans and technicians and possible training modifications, which were original (in 1992). Thus health service providers will need to:

* ensure healthcare technology skill development is incorporated into HRD plans, with sufficient representation of maintainers' needs;
* consider the advantages of the different options available for hiring and developing technical staff;
* investigate and make use of existing courses from trade, vocational, industrial, and academic training bodies (nationally, regionally, and internationally);
* collaborate with such training bodies and industry to develop new modular combinations, new 'trades', and industrial sponsorship, in order to produce entry-level staff for public and private sector maintenance organizations;
* make use of manufacturers' training resources (see Section 9.3);
* flag healthcare technology training as a specific and important component for the country programmes of external support agencies, and obtain scholarships for some requirements (see Section 10.7).

The necessary training of a wide variety of staff is a very important component of the healthcare technology package, and must be seen as a planned developmental process to spread technical knowledge wider within health service organizations (Section 6.2.2) and create a national technical management capacity. One development perspective of interest is the gender aspect; a large proportion of those requiring technical training are women. This training will require financing, and is discussed in Sections 8.3 and 8.4. At present, there are no regulatory systems that state that staff must receive equipment training.

As *Forbes* states, technology transfer is a human capability, and is not primarily a matter of whether or not rich country multinationals will hand over hardware or industrial property rights, but a matter of getting knowledge which is only in some foreigners heads into the heads of one's own nationals.[223] Thus a discussion of technical management capacity must be more than simply a discussion of skills, but must involve tacit knowledge and inspiration. One way to develop this is positive HRD practices. As *Forbes* summarizes, what matters for technical development is the capability of the people, the knowledge and aspirations they have in their heads, and how skilfully the government creates the conditions whereby people are motivated to give of their best.[223]

However, new personnel management techniques have been slow to arrive in the three countries studied. When *Halbwachs* spoke of the damage caused by equipment operators, he reported that "this is due in part to a lack of know-how, but also to socio-cultural factors in combination with primarily hierarchically defined styles of leadership that engender indifferent behaviour, lack of initiative, deficient sense of responsibility for public property, and finally an underdeveloped sense of ownership".[198] Good innovative personnel management techniques are part of Quality Management Systems, can motivate staff, and improve performance; these are crucial for the attitude and morale of equipment operators and maintainers. However the limitations of such initiatives must be acknowledged, by 2000 the salaries of technical staff in Zambian government hospitals was so low that they could not afford food during the working day – it is difficult to motivate staff who are hungry.[171]

In answer to my question "*can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?*", the research shows that there has been a mixture of small and large initiatives which have succeeded, many of which I have used in my subsequent work:

* organized in-house training to increase the equipment skills of operators (ie. the clinical engineering training unit in UTH, Zambia);
* practical maintenance training guide for equipment users (ie. Namibian MOHSS);[227]
* illustrated reference materials to aid purchase and supplies staff to identify items (ie. Botswanan Central Medical Stores, Kenyan Division for the Supply of Spare Parts[228]);
* inclusion of training in purchase/tender documents (ie. Namibian MOHSS);
* equipment management training for maintainers (ie. UK courses);
* development of a hospital administrator cadre (ie. Zimbabwean MOH);
* development of an establishment structure for the national equipment management service, with a first-level made up of general facility-level staff (ie. Namibian, Ghanaian, and Madagascar MOH);
* development of a national medical equipment maintenance training capacity (ie. Kenya, Senegal, ZCCM), which may also go on to be a regional resource;
* introduction of personnel management strategies (ie. Kgalagadi Breweries, Botswana).

In addition, there are a number of potentially useful initiatives which as yet have not been pursued by or for the health sector:

* introducing equipment-related modules in the basic training curricula for clinical, paramedical, and support staff;
* liaising with Trade Testing authorities to develop a new apprenticeable trade for medical equipment maintenance artisans, so they can attain qualifications;
* liaising with polytechnics and the Ministry of Education to combine a mix of existing diploma modules to produce entry-level general maintenance technicians, and possibly additional medical equipment options;
* liaising with industry (such as the mines) to make use of their training capabilities (for the role of the private sector see Chapter 9).

As Chapter 6 identified, absorptive capacity for technology will be increased if technical know-how can be spread amongst many more types of cadre. Countries such as Ghana, Madagascar and Namibia (2000 plans) are developing the first level of their national equipment maintenance service to comprise existing general health facility staff (see Section 6.2.2).[181,182,178] For the future, *Halbwachs* proposes that the supervision process developed for the district health system must stress the importance of all physical assets. Even when personnel with equipment management skills are not yet available, the normal supervisory health personnel could be trained to incorporate elements of equipment management in their support to the health services, using systematic appraisal protocols.[182]

Such strategies should be part of on-going health sector reforms, thus the role and strategies of external support agencies are investigated in Chapter 10. As *Johnson & Wilson* stated in 1998, it is not possible to think about sustainable development without thinking about building human capacity, and this must be at least one of the key outcomes of development activities.[229] However, the reality in many developing countries (such as Zambia by 2000) is that even though operator, technical, and management staff are in post and being trained, many are dying of AIDS-related illnesses – another feature, currently, of being a developing country.[171] The *Development* perspective of this Thesis continues in Chapters 8 – 10, with further examples that highlight major development issues.

CHAPTER EIGHT: SUFFICIENT ALLOCATION OF FINANCIAL RESOURCES

When taking a *Technological Systems* approach in Chapter 5, I identified sufficient allocation of financial resources as one of five fundamental overarching themes. Financial resources impact on the subject matter contained in all chapters of this Thesis. They are also indicators of a country's state of development. Thus in this Chapter, I continue the *Development* approach – my third theoretical perspective, started in Chapter 7. Study of resource availability provides examples of a number of major development issues, such as short-termism, decentralization, public/private partnerships, which will be continued in Chapters 9 and 10.

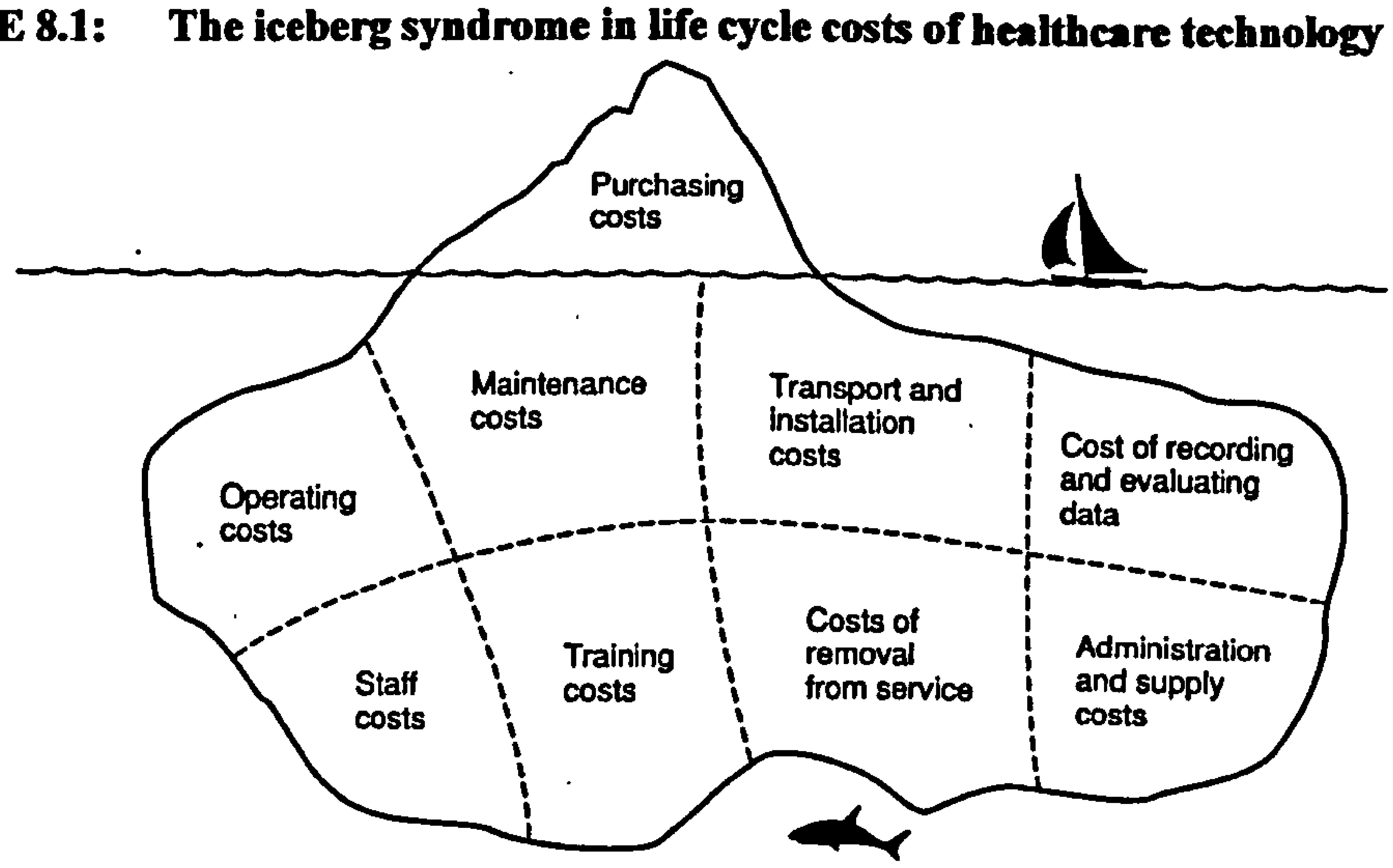
This Chapter continues the process of detailing the outcome of the country case studies, and looks at the availability, allocation, and management of finances for the equipment sector. It presents the constraints that arise and looks for assistance from literature covering health financing in developing countries. The study of financial data was undertaken predominantly in the public sector, thus this Chapter concentrates on the financial resources within the government-run health services. It looks to see if there are examples of innovations which would provide answers to my fourth research question:-

Q4 Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?

8.1 THE DIFFICULTY OF IDENTIFYING EQUIPMENT EXPENDITURE

Pfeiff points out that there are a variety of costs related to equipment, most of which are hidden; he illustrates this with the image of an iceberg as shown in Figure 8.1.[103]

FIGURE 8.1: The iceberg syndrome in life cycle costs of healthcare technology



Source: Pfeiff, H., 1986, 'Hospital Engineering in Developing Countries – Tasks and Decision-making Aids for Coping with the Problem', in Damann, V. & H.Pfeiff (eds), Hospital Engineering in Developing Countries, GTZ[103]

As reported in Section 2.3.3, a number of countries experience a recurring cycle in the financing of the equipment sector: new equipment is purchased; its effectiveness decreases rapidly due to unskilled use, poor maintenance, and insufficient investment to support it; a crisis occurs because so much technology is non-functioning that service delivery is compromised; and a new round of procurement takes place (Figure 2.8). Funds for purchases may be found locally during a period of relative prosperity, or from an external support agency. This cyclical approach to funding is costly and provides little benefit to patients, since the quality of the health service delivered is never constant and goes through frequent periods of deterioration.[3]

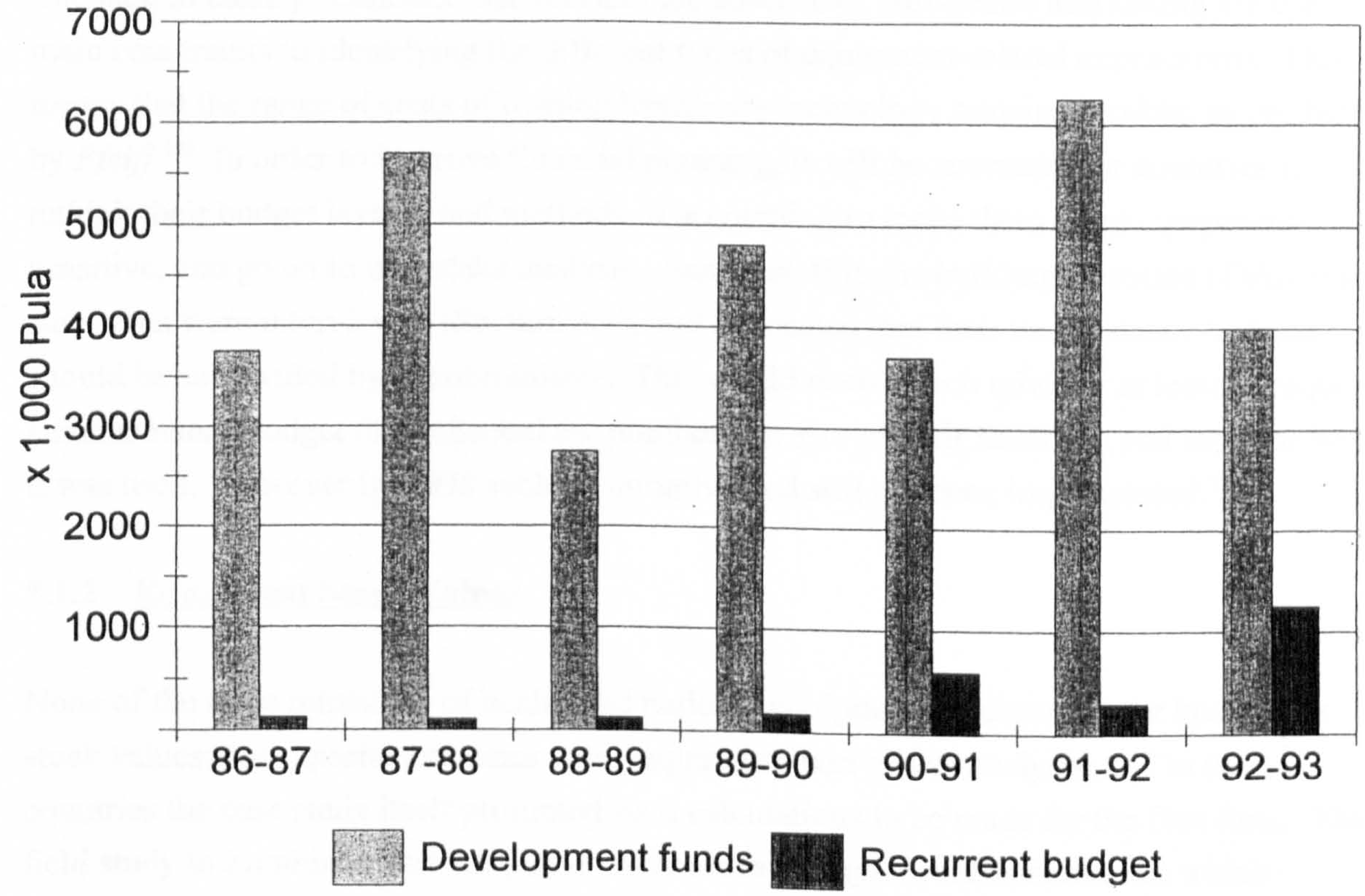
It is preferable to have a planned approach to financing equipment, based on a realistic estimate of needs. To adequately analyze the financing required, you need i) expenditure records of sufficient detail to identify equipment-related costs; and ii) an equipment stock value from which percentages can be calculated, according to internationally recognized guidelines, which will indicate the annual resource requirements to sustain the system. Only then will it be possible to plan future financing of the equipment sector against a clear idea of the quantity and cost of equipment in use and its state of repair. The research in three case study countries found that such information was hard to come by, thus as part of the field work such data had to be extrapolated and as such is mostly original. Much of the data in this Chapter was produced by such analysis.

8.1.1 <u>Expenditure Records</u>

In Zambia (1990), it was difficult to identify what had been spent on equipment as there were no specific equipment expenditure records. Nor was it possible to analyze in any detail how funds were spent because of the ill-defined structure of hospital and general health budgets. Although there were overall maintenance budget lines, much of the funds went on upkeep of buildings and purchase of common plant consumables (light bulbs, elements, etc), rather than on maintenance of medical equipment. In Botswana, it wasn't until 1994 that a Chief Hospital Engineer was appointed and undertook a special exercise to estimate past expenditure on medical equipment; he achieved this by studying background records in order to extract equipment figures out of the normal budget lines and vote totals which were not equipment specific.[71]

His findings are summarised in Figure 8.2, and show that annual development funds for the expansion of medical equipment fluctuated from US$ 1.3 million (2.75 million Pula) to US$ 3 million (6.25 million Pula) over 7 years, whilst the recurrent budget grew slowly from US$ 59,500 (125,000 Pula) to US$ 536,000 (1.125 million Pula) per annum.[71] The Department of Works' buildings division and electro-mechanical division were responsible for maintaining all government facilities within the public sector, and their maintenance budgets were sub-warranted to their depots throughout the country. However budgets were not divided by facility or even client ministry, so DOW was unable to tell the MOH what had been spent on the maintenance of its assets. Supposedly DOW was responsible for the replacement of old assets (plant and service installations) for all government facilities, but no formal procedures existed for establishing spending priorities.

FIGURE 8.2: Government expenditure on medical equipment in Botswana from 1986/7 – 1992/3



Source: Special Study by the Chief Hospital Engineer, MOH, Botswana, 1994[71]
In 1992, US$ 1 = 2.1 Pula

In Namibia (1997), it was almost impossible to ascertain what had been spent on equipment. It was difficult to extract equipment details from MOHSS budgets showing past expenditure, as they were incorporated under general sub-division codes. MOHSS complained that the DOW allocation figures for health facilities, and actual expenditure on equipment and maintenance were not readily available or transparent.

Frequently health service budgets are not: structured to delineate sufficiently the different types of expenditure (ie. the cost of equipment within building construction plans); sensitive enough (ie. to show maintenance of medical equipment separate from maintenance of vehicles); broken down in sufficient detail (ie. to identify expenditure on equipment consumables within the total for medical supplies); or sufficiently differentiate between expenditure points (ie. to show equipment expenditure by facility). Equipment plays an important role in healthcare delivery, but it can be compromised by the absence of necessary inputs. If expenditure on equipment inputs cannot be tracked, the service interruptions that result from the shortage of equipment-related funds cannot be prevented.

The lack of clearly delineated budgets and the absence of cost-centre accounting are the main constraints to identifying the different types of equipment-related expenditure. This means that the range of costs of owning healthcare technology remain invisible, as predicted by *Pfeiff*.[103] In order to improve financial planning, it will be necessary for countries to rethink their budget layouts and methods of accounting to make them more equipment-sensitive, and go on to undertake analysis. Senior staff in the buildings division (DABS) in Botswana were interviewed (Section 3.3), and advocated that their maintenance budgets should be subdivided by client ministry. This would enable each ministry at least to request a maintenance budget that reflected the number and size of their facilities, and monitor how it was used. However by 1998 such an initiative had still not been implemented.[177]

8.1.2 Equipment Stock Values

None of the three ministries of health had national equipment inventories, nor knew their stock values; thus special estimates were required as part of this analysis, and in two countries the case study itself prompted such calculations to be made for the first time. The field study to Zambia undertook partial inventories of eight health institutions, which enabled rough guestimate of the stock value for the country as a whole assuming only the existing basic level of medical equipment and plant were replaced. The breakdown by major facility type is shown in Table 8.3, and the total was taken to be US$ 86 million (3,010 million Kwacha[t]) although no calculations were made for health centres.[69]

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t See footnote p. (Chapter 7)

TABLE 8.3: Guestimate of basic level medical equipment & plant stock value, Zambia 1990		
Type of institution, Zambia 1990	Average US$ per hospital	Total US$
University Teaching hospital (1000 bed)	12,000,000	12,000,000
Ndola central referral hospital (800 bed)	8,000,000	8,000,000
Kitwe central referral hospital (400 bed)	5,000,000	5,000,000
Arthur Davison paediatric hospital (300 cot)	2,000,000	2,000,000
9 government general hospitals (400 bed average)	2,000,000	18,000,000
22 government district hospitals (120 bed average)	900,000	19,800,000
30 mission hospitals (120 bed average)	600,000	18,000,000
4 government special hospitals (500 bed average)	500,000	2,000,000
3 government rural hospitals (50 bed average)	400,000	1,200,000
		86,000,000

The Botswanan Medical Equipment and Maintenance Service undertook an exercise in 1989 to estimate the value of the complete government stock of medical equipment (only). Table 8.4 shows that MEMS estimated the total to be worth approximately US$ 34.5 million (72.5 million Pula) excluding health centres; this reflects better equipment stock levels compared to Zambia. However, the total stock value soon proved to be an underestimate as the 7th National Development Planning period (1991 – 1997) saw the completion of the upgrading of Princess Marina central hospital, 2nd phase upgrading of existing primary hospitals, and construction of new primary hospitals. The Ministry of Works did not have inventories of the plant and service installations in health facilities, from which to calculate a stock value.[71, 208]

TABLE 8.4: Guestimate of medical equipment stock value, Botswana 1989		
Type of institution, Botswana 1989	Average US$ per hospital	Total US$
Princess Marina central referral hospital (350 bed)	7,100,000	7,100,000
Nyangabgwe central referral hospital (350 bed)	4,800,000	4,800,000
7 government district hospitals (160 bed average)	1,900,000	13,300,000
15 government primary hospital (40 bed average)	620,000	9,300,000
		34,500,000

During the field study to Namibia (1997), the Planning Directorate of the MOHSS guestimated the value of the equipment stock (medical equipment and hospital furniture) that they maintained to be approximately US$ 50.96 million (N$ 232 million[u]). They also roughly estimated the value of key MOHSS' plant that the Department of Works (DOW) maintained to be US$ 29.2 million (N$ 133 million), but the value of the service supply installations and general furniture were not calculated. Their calculations were not made by facility but by the numbers of different types of equipment they knew were placed around the country, as shown in Table 8.5.[73]

u. See footnote q. (Chapter 7)

TABLE 8.5: **Guestimate of equipment stock values, Namibia 1997**

A: Equipment maintained by MOHSS	US$
Cancer care centre, Windhoek (2 x gamma cameras, 1 x cobalt unit, 1 x simulator, 1 x after-loader, 1 x C-arm, 2 x film processors, etc)	3,500,000
CT scanners (1 x central unit)	1,100,000
X-ray machines (all equipment from radiographic Services inventory including standard suites, fluoroscopy suites, and film processing)	11,000,000
Anaesthetic machines, vaporizers, and anaesthetic ventilators (all equipment from service contract list - 120 operating theatre suites)	4,400,000
Laboratory equipment (all equipment from Laboratory Services inventory)	5,500,000
Operating tables (1 per 120 operating theatre suites, averaged for varying complexity)	3,700,000
Operating lights (1 per 120 operating theatre suites, averaged for varying complexity)	2,000,000
Infant incubators (100 x units in WHC, 50 in Oshakati, 210 elsewhere in 35 hospitals)	2,350,000
Transport incubators (35 x units countrywide)	400,000
All monitors (1 standard unit per 120 operating theatres, & 30 x more-sophisticated units in the 7 ICU/high care units)	3,180,000
Defibrillators (22 units in WHC, 8 in Oshakati, 70 elsewhere in 35 hospitals)	1,540,000
Diathermy units (1 per 120 operating theatre suites)	1,750,000
Ultrasound scanners (35 countrywide, averaged for varying complexity)	1,200,000
ICU ventilators with air-compressors (4 standard units in WHC, 6 in Oshakati, 5 elsewhere in country & 8 x more-sophisticated in WHC)	440,000
All other medium to low technology equipment and hospital furniture	8,900,000
Total	50,960,000

B: MOHSS' plant maintained by DOW	US$
Autoclaves (100 x units countrywide)	2,630,000
Laundry equipment (large capacity in WHC, 31 x small sets, 2 x medium sets)	9,060,000
Incinerators (at 37 locations)	3,300,000
Kitchen equipment (small sets in 31 locations, large sets in 3 locations, very large set at WCH)	2,200,000
Air-conditioning (310 individual units in 31 hospitals, 150 in 3 hospitals, 20 central plants at 6 hospitals)	3,200,000
Mortuaries (9-body capacity in 31 locations, 30-body capacity in 1 location, 50-body capacity in 1 location, 100-body capacity in 1 location)	1,010,000
Refrigeration (1,820 individual units in 236 locations, 40 cold rooms, 36 freezer rooms, 1 large capacity freezer room)	1,430,000
Electrical generators (31 small sets, 4 large sets)	1,900,000
All other various items such as geysers, pumps, compressors, boilers	4,470,000
Total	29,200,000

It is difficult to manage an unknown. The absence of equipment inventories severely limited both the health service providers' and the public sector maintenance organizations' ability to manage their assets. In Namibia, the case study reported here prompted the MOHSS to: hire a private sector equipment company to design and undertake a national inventory; make policy proposals for significant changes to the layout of the budget and the means of calculating it, in order to take into account equipment needs; and estimate equipment stock values. This latter 'tool' is important for developing countries if they are to start analyzing equipment expenditure and calculating annual resource requirements (see subsequent sections in this Chapter). When discussing health economics for developing countries, *Witter et al* explain that cost information is a vital managerial tool.[230] It should be used to compare efficiencies and prioritize between different interventions. As they point out, it is necessary to predict costs in order to plan services for the future whilst staying within budget, and such predictions will only be of value to developing countries if they are based on the real situation.

Notwithstanding the difficulty of identifying equipment expenditure, the case studies provided an opportunity to investigate specific equipment financial data and calculate various forms of expenditure. The rest of this Chapter describes the findings; they are summarized in Table 8.6 in order to offer a comparison between the countries.

8.2 CAPITAL EXPENDITURE

In most countries, capital funds are used to cover large one-off expenses such as replacing equipment at the end of its life, or buying additional equipment when an expansion of services is planned; these requirements are normally estimated annually. Replacing existing equipment is very important as it maintains the status quo within the health service. For example, if a country wants to continuously provide a dental service, the drilling unit must be replaced at the end of its life for the service to continue; purchase of replacement drilling units is not an expansion in services, merely a continuation of existing provision.

As detailed in Section 2.3.4, equipment needs to be replaced within 5 – 20 years depending on technology type.[41] However, the useful life of equipment can be shortened by a harsh environment, frequent use, unskilled handling, neglect of preventive maintenance, and lack of spare parts and specialized technicians. By taking the average life-time at 10 years, a reasonable estimate of the cost to retain the status quo of the health service is 10% of the technology stock value every year. If many years pass without an annual replacement budget, health service providers find a critical reduction in the health services they can deliver and, as *Temple-Bird* warned, ultimately face the major capital investment implications of undertaking bulk replacements all at once, to cover the backlog.[231]

During the three case studies, attempts were made to analyze the capital funds used on new or replacement equipment. As stock values were unknown nor used as a financial tool, equipment expenditure was expressed as a percentage of the total health budget. Although the ministries felt this was a useful indicator, it bears no relationship to equipment and does not measure its well-being. For comparison, I use here the guestimates of the equipment stock values (Section 8.1.2) and the 10% average replacement guideline (quoted above) in order to determine the replacement budgets that are required.

TABLE 8.6: A summary and comparison of equipment financing in the three countries studied			
	Zambia, 1990 (US$)	**Botswana, 1992[1] (US$)**	**Namibia, 1997 (US$)**
Annual MOH[2] total health budget (THB)	Total: 41.2 million {Development:8.1 mill Recurrent: 33.1 mill[3]}	Total: 38.1 million[4] {Development: 12.8 mill Recurrent: 25.3 mill}	Total: 199 million {Development: 16.2 mill Recurrent: 182.8 mill}
Estimated equipment stock value (S)	86 million basic med.eqt & plant	34.5 million medical equipment	51 million med.eqt & hosp.furniture (plus 29.2 million for plant under DOW)
Replacement Guide: 10% of S = average replacement budget (GR)	8.6 million	3.45 million	5.1 million (8.02 million if plant included)
What GR would be as % of THB	21%	9.1%	2.56% (4.03% including plant)
Actual: replacement expenditure (AR)	86,000 - 412,000[5]	31,000 - 476,000[6]	27,000 - 1.45 million[7] {med.eqt only}
AR as % of stock value (cf.10% guide)	0.1 - 0.48%	0.09 - 1.4%	0.05 - 2.84%
AR as % of THB	0.21 - 1%	0.08 - 1.25%	0.14 - 0.73%
Maintenance Guide: % of S = maintenance budget (GM)[8]	4.3 million {5% as average of med.eqt & plant guides}[9]	2.1 million {6% as med.eqt guide}	3.1 million {6% as med.eqt guide} (plus 1.17 mill.for DOW plant using 4% guide)
What GM would be as % of recurrent budget (RB) only	13%	8.3%	1.7% (2.34% including plant)
Actual: maintenance expenditure (AM)	unknown for country as a whole[10]	21,500 - 185,700[11]	<570,000 - 943,000[12,13]
AM as % of stock value, S	<0.16 - 1.57%[10,13] {cf.5% for mixed eqt}	0.06 - 0.54% {cf. 6% for med.eqt}	<1.12 - 1.85%[13] {cf. 6% for med.eqt}
AM as % of RB	<1.55 - 6.53%[10,13]	0.09 - 0.73%	<0.31 - 0.52%[13]
Life-time Costs Expenditure on consumables, training, etc[14]	unknown	unknown	unknown

1. The figures for Botswana are from a number of different years, as detailed in the notes.
2. In Botswana, the additional health budget given to the Ministry of Local Government, Lands, and Housing to run clinics is omitted.
3. The actual development-recurrent split in Zambia for 1990 is unknown, but the ratio trends from previous years were used.
4. These budget figures are from 1988/89.
5. The lower figure is from 1990, the higher figure is an MOH estimate for previous years.
6. The lower figure is from before 1990, the higher figure is by 1992/1993.
7. The lower figure is from 1994/95, the higher figure is from 1995/96.
8. The % used varies depending on the type of equipment: 6% for medical equipment; 4% for plant; 3% for buildings.
9. The 6% guide for medical equipment and 4% guide for plant are averaged, & 5% used for the combined mixed stock value in Zambia.
10. No national data available, but examples of allocations to specific institutions were calculated for 1989 & 1990 (see Table 8.8).
11. The lower figure is from 1985/86, the higher figure is from 1992/93.
12. The lower figure is from 1994/95, the higher figure is from 1997/98.
13. Figures cover all maintenance (Zambia: includes buildings & installations; Namibia: includes vehicles & office equipment), thus the actual available for medical equipment is less.
14. Equipment life-time costs were lost amongst all the other health service running costs, and could not be extracted for analysis.

In Zambia, it was not possible to determine from records past capital expenditure on equipment. Since the drop in copper prices and the economic downturn from the mid-70s, the MOH had limited capital funding available for purchasing equipment. MOH senior staff estimated that replacement spending had probably averaged less than 1 or 2% of the health budget (capital and recurrent combined) per annum over the previous 15 years.[160] As Table 8.6 shows, in 1990/91 the US$ 86,000 available for medical equipment and plant was 0.2% of the total annual health budget. This allocation for equipment purchasing was only 0.1% of the equipment stock value estimate. By comparison, using the stock value estimates and 10% calculations, the annual replacement budget should have been US$ 8.6 million. This would have used 21% of the health budget for 1990/91. Equipment was in a severe condition (Section 5.1.1), and Zambia urgently needed to replace or rehabilitate most equipment and plant at government hospitals. A good part of this represented deferred annual replacement. Because these needs had been underfunded for such a long time, the bulk replacement required would be at substantial cost[v].

Under the 6th National Development Plan (NDP) in Botswana (1985 – 1991), expenditure by the MOH on healthcare technology rose from less than US$ 390,000 (800,000 Pula) in 1985/6 to over US$ 6.7 million (14 million Pula) in 1990/1, as shown in Table 8.7.[233,234] These figures over-estimate the amount of money spent, since they include furniture, vehicles, and medical supplies. The total also includes recurrent as well as capital (development) votes. According to the Finance Officer, money for replacement of existing equipment should come from the recurrent vote, and newly expanded capacity or donor-funded purchases should be included in development projects, although the rules were unclear. Since the MOH substantially expanded its infrastructure during NDP6, most of the money spent on equipment came from development projects and was for the purchase of new additional items as part of the upgrading of two central referral hospitals, Phase 1 upgrading of primary hospitals, and construction of the National Public Health Laboratory. In contrast, the MOH did not allocate sufficient funds for the equipment replacement required to maintain adequate levels of service delivery in facilities excluded from development projects. Table 8.7 shows that the total expenditure on all types of equipment and supplies net the hospital upgrading programmes only rose from US$ 377,000 (791,000 Pula) in 1985/86 to US$ 1.3 million (2.7 million Pula) in 1990/91.

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v. By 2000, I estimated that as much as 95% of equipment, plant, & service installations in three central referral hospitals required replacing. Only 5% of the stock could be rehabilitated through maintenance (*Temple-Bird*).[232]

TABLE 8.7: Government expenditure on furniture, equipment, and supplies in Botswana during 1985/6 – 1990/1 (in Pula)

Subhead item [1,2]	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	Total
RECURRENT							
Hospital Services							
0305/ Orthopaedic equipment (implants)	0	0	0	2,910	10,521	337,336	350,767
0308/14 Medical and surgical equipment	3,185	64,848	13,830	22,539	18,471	474,056	596,929
PHC Services							
0404/11 Dental equipment supplies [3]	69,467	85,315	160,314	91,503	125,028	81,439	613,066
0404/47 Orthopaedic prostheses and supplies	19,753	23,743	38,768	56,486	81,459	65,154	285,363
0404/51 Audiological equipment	2,338	3,417	7,241	7,330	8,764	25,345	54,435
0404/52 Graphic equipment	767	7,346	9,601	13,639	20,173	21,596	73,122
0408/14 Medical and surgical equipment	0	0	0	1,800	1,795	84	3,679
TS Services	218,150	331,350	375,620	658,557	745,709	1,050,873	3,380,259
0508 Lab minor equipment and supplies [3]							
Sub-total	313,660	516,019	605,374	854,764	1,011,920	2,055,883	5,357,620
CAPITAL							
2 National Health Institute	0	7,517	0	0	0	0	7,517
3 Hospital Services (referral Hospitals)	77,244	3,661,776	5,164,760	4,631,494	4,603,452	11,463,565	29,602,291
4 Primary Health Care	69,213	66,464	582,853	2,304,580	624,857	447,013	4,094,980
5 Technical Support Services	336,021	25,920	704,321	1,658,065	1,478,195	144,745	4,347,267
Sub-total	482,478	3,761,677	6,451,934	8,594,139	6,706,504	12,055,323	38,052,055
TOTAL	**796,138**	**4,277,696**	**7,057,308**	**9,448,903**	**7,718,424**	**14,111,206**	**43,409,675**
Including referral hospital upgrading							
Princess Marina Hospital (capital) [4]	5,053	286,152	12,758	70,666	400,626	8,313,945	9,089,200
Nyangagbwe Hopsital (capital) [4]	0	3,375,624	5,164,760	4,551,413	4,152,855	3,141,462	20,386,114
Total (Net of referral hospital upgrading)	**791,085**	**615,920**	**1,879,790**	**4,826,824**	**3,164,943**	**2,655,799**	**13,934,361**
TSS maintenance budget (spare parts and payment to private companies)	45,151	105,095	77,306	69,792	108,690	144,745	550,779

Sources: 1985/86 – 1989/90 Annual Statement of Accounts, 1990/91 Year end accounts (computer printout)

1 Expenditure shown in Pula, in 1992, 2.1 Pula = US$1
2 The data presented on capital projects are the amounts of purchases charged against the item "furniture and equipment". It was not possible to identify medical equipment on its own. At times funds allocated for building works may be utilised for purchases of equipment
3 90 per cent of each item is on supplies
4 Includes plant and vehicles

The recurrent budget should show the monies spent on replacement equipment, but it was impossible to extract expenditure on equipment from that for supplies. Table 8.7 shows that over the six-year period, total recurrent expenditure on equipment and supplies was US$ 2.6 million (5.4 million Pula). The Chief Hospital Engineer calculated that US$ 1.6 million of this was spent on small items of equipment (eg. stethoscopes, laryngoscopes, sphygmomanometers) and medical supplies stocked by the Central Medical Stores. The Hospital Services Division, responsible for buying the substantial items of medical equipment, spent only US$ 285,000 (597,000 Pula) over six years. This would explain why district hospitals excluded from the upgrading programmes under NDP6, had complained for years of a lack of funding for equipment.[235]

Thus for analysis, it was preferable to use the Chief Hospital Engineer's figures from his special exercise on medical equipment (Table 8.2). As Table 8.6 shows, expenditure on medical equipment out of the Hospital Services recurrent vote (ie. for replacement) was US$ 31,000 in 1990; only 0.09% of the stock value. This expenditure rose to over US$ 476,000 by 1992/93, but was still only 1.4% of the 1989 stock value that by this time was out of date. Using the 1989 stock value estimates and 10% calculations, the annual replacement budget should have been US$ 3.45 million for medical equipment in hospitals (the basis of the stock estimates). This would have used 9.1% of MOH's total budget or 13.6% of the recurrent portion of the budget, intended for replacement.

The limitations of interpreting the budget expenditure codes in Namibia made it difficult to extract expenditure on equipment. For example, the development budget for 1997/1998 provided only US$ 834,000 for 'furniture and medical equipment', with additional monies for 'plant and x-ray machines' rolled into the overall 'construction costs' of US$ 12 million. Supposedly expenditure for replacement came from MOHSS's recurrent budget, but the Deputy Director of Planning stated that in reality replacement only occurred when a hospital was upgraded under the development budget. Some health facilities lacked the required functioning equipment, and provision was skewed across the country. Recurrent expenditure on 'furniture and equipment' had fluctuated significantly over the previous four years with actual expenditures of US$ 27,000 in 1994/5 and US$ 1.45 million in 1995/6, and budget allocations of US$ 436,000 for both 1996/7 and 1997/8.[236] Hidden within these figures were some budget-holders (different ministerial divisions) with no allocation, or a lot one year and little the next. Table 8.6 shows that with a 1997 stock value of US$ 51 million, the best figure represents only 2.84% of the stock value. By comparison, using the stock value estimates and 10% calculations, the annual replacement expenditure by MOHSS should be US% 5.1 million. This would use 2.56% of MOH's total budget, or 2.78% of the recurrent portion of the budget intended for replacement.

These calculations only take into account medical equipment. Department of Works' budgets were meant to finance plant replacement, although they were mainly used for new buildings and minor capital works. Table 8.6 shows that, using the stock value estimates and 10% calculations, the annual replacement budget for MOHSS' plant (excluding service supply installations) should be US$ 2.92 million. If DOW was not allocated these funds, this would raise MOHSS's annual replacement bill to US$ 8.02 million; 4.03% of the MOHSS's total budget.

The analysis shows that all threes countries had no budgeting for depreciation, and it was common for ministries of health to cover replacement needs by using development funds allocated for discrete facility upgrading projects. Although this approach helped on a one-off basis it was not a regular occurrence, and the problem remained of facilities falling outside upgrading programmes as well as immediate needs for those waiting several years for upgrading to begin. Consequently, ministries of health ran health services without adequately budgeting for equipment replacement, and faced disastrous results in the state of their equipment stock.

Due to a lack of annual replacement budgeting, Zambia by 2000 urgently needed to undertake bulk replacement or rehabilitation of most equipment and plant in government hospitals. The government is unable to afford this, and there are no signs that the international community is willing to finance such activities.[171] It is discouraging that *Bloom et al* note that there is a familiar pattern amongst developing countries; ministries of health fail to adequately budget to maintain the status quo of their equipment stock.[86] Thus alternative budgeting strategies and initiatives are required to continually cater for annual replacement requirements.

8.3 RECURRENT EXPENDITURE

Budgets are required for the maintenance of equipment so that its full life-time can be attained. In addition, budgeting for consumables and other expenditures (such as installation and training) is needed so that equipment can be used effectively throughout its life.

8.3.1 Budgeting for Maintenance and Repair

All equipment comprises various parts both moving and non-moving, active and passive. At any time, these parts can fail due to wear and tear. Thus, it is necessary to give regular attention to equipment throughout its life, either by checking to ensure parts are alright and replacing them as necessary (ie. maintenance), or by responding to and correcting any breakdown (ie. repair). However, the nearer equipment gets to the end of its life the more frequent, expensive, and potentially uneconomical maintenance and repair becomes.

Even with the known benefits of maintenance, projections of recurrent costs of new facilities and programmes often fail to take into account the need to fund the activities required to sustain the equipment service. One example is the Sokode Hospital in Togo which was evaluated by the *French Ministry of Foreign Affairs, Cooperation, and Development*.[237] Expenditure on maintenance of building and contents was found to be much lower than that required to keep it in running order. Although a maintenance technician was on site, his effectiveness was seriously impaired by lack of spare parts and specialised tools. Two years after completion, several pieces of equipment were already not functioning and the report concluded that the process of degeneration would accelerate if additional funds were unavailable. Another study undertaken in Kenya by *Halbwachs* found a similar situation for the health sector as a whole, where maintenance expenditure was less than one percent of the replacement value of the equipment stock.[89]

In order to provide a continuing service, it is necessary to allocate a percentage of the equipment stock value each year for maintenance (separate from replacement). In the *Bloom & Temple-Bird* study where UK firms were interviewed, the medical equipment industry proposed an allocation between 10 and 15 per cent especially for equipment located a long way from the manufacturing country.[3] The experience of the British National Health Service is rather similar; the *Health Service Supply Council* reported in 1984 that the cost of maintenance generally ranged from 6 – 10 % of the purchase price.[88] International experts have consolidated these ideas across different equipment types, and suggest that maintenance and repair costs ought to be around: 5 – 6% of stock value per year for medical equipment, 2 – 3% of construction costs for buildings per year, 3 – 4% of purchase and installation costs per year for service supplies and plant [8,86,182,238]

In Zambia the equipment stock value estimate was for medical equipment and plant, so for the calculations in this analysis I used a combined average estimate, from the international guidelines, of 5%. Table 8.6 shows that the annual maintenance budget should have been US$ 4.3 million per annum, 13% of the (estimated) recurrent health budget for 1990/91. During the case study, details of maintenance allocations were determined for the health institutions visited.[239] Table 8.8 shows the outcome for 1989 and 1990. The maintenance allocations never reached the guideline 5% of stock value for equipment and plant, and rarely reached 1%. To make matters worse, these allocations covered expenditure on all maintenance needs, including buildings and infrastructure. Since the government likes to express the maintenance budget as a percentage of the total facility allocation, this is also presented. Table 8.8 shows that this indicator hides the true extent of the under-funding of maintenance activities, and is no measure of the likelihood of sustaining the well-being of the equipment stock.

TABLE 8.8: Maintenance expenditure[1]: selected Zambian hospitals & provincial authorities[2]					
	Univ.Teach. Hosp. (1000 bed)	Ndola Cent. Ref'l Hosp. (800 bed)	Kitwe Central Referral Hosp. (400 bed)	AD Paediatric Ref'l Hosp. (300 cot)	Central Province Med.Office[3]
US$ estimated stock value (S)	12,000,000	8,000,000	5,000,000	2,000,000	4,900,000[4]
1989:					
Maint.allocation	57,000	12,600	13,200	14,100	25,100
As % of S	0.48%	0.16%	0.26%	0.71%	0.5%[5]
Total allocat'n (T)	2,960,000	808,500	568,300	329,400	776,600
Maint as % of T	1.93%	1.55%	2.32%	4.28%	3.23%
1990:					
Maint.allocation	172,000	39,900	43,400	31,400	28,000
As % of S	1.43%	0.5%	0.87%	1.57%	0.57%[5]
Total allocat'n (T)	5,700,000	1,066,000	926,300	481,000	1,057,300
Maint as % of T	3%	3.74%	4.69%	6.53%	2.65%

1. Includes maintenance of buildings and infrastructure.
2. Source: Republic of Zambia, Recurrent and Capital Estimates for the Year 1st January 1990 to 31st December 1990, Lusaka.[239]
3. The government facilities in Central Province were: 1 special hospital, 1 general hospital, 2 district hospitals, and 1 mission hospital which was government owned, as well as 100s of health centres.
4. Derived from the stock values for the types of hospitals in the province, shown in Table 8.3.
5. This calculation did not take account of the unknown stock value of the health centres in the province.

In Botswana the equipment stock value estimate was for medical equipment, so for the calculations in this analysis the international guideline of 6% is used. Table 8.6 shows that the annual maintenance budget should have been US$ 2.1 million per annum, 8.3% of the recurrent health budget for 1989. Instead the MOH was spending very little on MEMS; the amount rose from US$ 21,430 in 1985/86 to US$ 185,700 in 1992/93. At best this was only 0.54% of the equipment stock value. Although much of the equipment stock was purchased under facility construction and upgrading programmes in NDP6 (1985 – 1991), the growth in maintenance budgets lagged far behind this stock increase. Thus, funds had been unavailable for introducing systems such as planned preventive maintenance, and the results were accelerated rates of deterioration of equipment.

When interviewed, the Superintendent of Works in Botswana stated that the maintenance budget for DABS should be at least 2% of the capital value of the buildings and services for which they were responsible. However, the value of government buildings was unknown because an exercise to ascertain their value, which began in 1985, was still incomplete. He argued that the 1992/93 allocation of under US$ 2.4 million, which did not include labour costs, was not nearly enough for the maintenance of buildings, water supply, drainage, plumbing fittings, and bathroom fixtures for government facilities nationwide. Similarly, DEMS' senior officers estimated that their 1992/93 budget was 30% below requirements.[71]

In Namibia, MOHSS's recurrent budget provided a blanket maintenance allocation covering vehicles, office equipment, furniture, medical equipment, and general maintenance. Table

8.6 shows that this expenditure had risen from US$ 570,000 in 1994/95 to US$ 943,000 in 1997/98. At best this was only 1.85% of the stock value of medical equipment, and was in fact considerably less since it covered all other types of equipment too. Using the medical equipment stock value and the 6% international guideline, the annual MOHSS maintenance budget should have been US$ 3.1 million. Interestingly, this was only 1.7% of the recurrent health budget and thus would appear to be affordable.

TABLE 8.9: Fluctuations in the maintenance budget at WHC, Namibia

Maintenance budget (US$)	1995/1996		1996/1997		1997/1998	
	Allocation	Expenditure	Allocat'n	Expend'e	Allocat'n	Expend'e
Med.equipment	245,600	329,000	245,600	394,700	225,900	329,000[3]
Other equip't[1]	131,200	84,500	9,900	4,700[2]	134,900	
Total	**376,800**	**413,500**	**255,500**	**399,400**	**360,800**	

1. Communication, cleaning, and office equipment, refrigerators, and hospital furniture.
2. Actual expenditure was greater due to virementation of funds from elsewhere.
3. Already spent in the first 8 months of the financial year.

Table 8.9 shows the fluctuating maintenance budget for the Windhoek Hospital Complex – comprising two referral hospitals. It shows that whilst maintenance expenditure for medical equipment went up, the allocation decreased. Although the maintenance department was allowed to overspend, this did not trigger a greater budget the following year.[240] The decentralized Regional Directorates reported receiving anything from 80% to 10% of their requested maintenance allocation from MOHSS.[241] Table 8.6 also shows that by using the plant stock value estimate and the international guideline of 4%, the annual plant maintenance budget should be US$ 1.17 million. DOW budgets were notoriously low; consultants estimated that it received on average one third of its required funds.[175] If MOHSS had to cover these costs their annual maintenance bill would rise to US$ 4.27 million; 2.34% of the recurrent health budget. These examples illustrate the difficulty of managing equipment and maintenance with allocations continually too low, and funding constantly cut.

Technology can only be used at its optimum performance level if it is regularly maintained, and adequate financial resources for these activities must be planned for. Table 8.6 shows that it is common for countries to have maintenance budgets less than 1% of the equipment stock value, making it impossible to keep their equipment functioning or safe. In reality developing countries may have to use higher calculations than other countries for maintenance, due to the age of their stock, the distances to cover, and the importation of materials. In Namibia's case the real maintenance expenditure required was calculated as 1.7% of the recurrent health budget and appears affordable, but less than one-third of this was allocated.

More recently, some countries have initiated a central dictate to hospitals and regional authorities for a mandatory percentage of their budget allocations to be used for maintenance. By 2000, the Zambian government had introduced a guideline requirement for its hospital boards (semi-autonomous facilities) to put aside for maintenance 10% of their recurrent budget allocation net salaries.[171] To see what this would mean, I have taken the example of the University Teaching Hospital and in real terms this represents less than 1.66% of the equipment stock value[w]. In addition, many countries are give a degree of financial autonomy to facilities trying some cost recovery strategies. Some countries pay over fixed amounts of income from treatment fees and sales of medicine to help cover district-level maintenance expenses; in Kenya for example, the ministry of health has ordered this to be a minimum of 25%.[243] However experts do warn that in the foreseeable future, it is unlikely that the governments of many developing economies will be able to bear the required maintenance funding on their own, even with such initiatives. They call upon the donor community to assist countries to develop adequate equipment management systems and contribute to recurrent expenditures for maintenance (see Section 10.8).[243]

A different initiative has started in Namibia. The Ministry of Works, Transport, and Communication is planning to sell off a certain part of government fixed property – property not in government use and all residential properties, except staff accommodation in remote areas. The estimated turnover of these sales is approximately US$ 660 million (N$ 3 billion) which when invested would generate US$ 99 million (N$ 450 million) per annum based on their present interest rate of 15% pa. Part of these funds will be used for general maintenance of the remaining government facilities, and the rest may be used for staff housing in remote locations.[175] The outcome of these initiatives is still unknown.

8.3.2 Other Life-Time Costs

Many pieces of equipment use consumable items (x-ray film, laboratory reagents, fuel, etc). They also require other expenditures if they are to function correctly, eg. transport, site preparation, installation, training, utility costs. The cost of these inputs must be met throughout the equipment's life if it is to continue to provide a service, and are known as 'life-time costs'. Commonly, facilities are unable to function effectively during much of the year because they cannot obtain consumable and other inputs, many of which are imported or contracted. These costs should be included in expenditure plans, and taken into account when decisions are made about equipment purchases. Planners often fail to realize that each year the operating costs can range from 5 – 100 % of the procurement costs.[244]

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w. In 2001, the estimated annual budget allocation to UTH, net salaries, was 4,200 million Kwacha; with a (reduced) exchange rate of US$1 = 2,415K, this amounts to US$ 1.99 million. The 10% for maintenance = US$ 199,000, only 1.66% of the 1990 stock value estimate of US$ 12 million.[242]

In all three countries, it proved impossible to extract the running costs of equipment from recurrent budgets. Equipment consumable costs were hidden in budgets that covered general supplies (eg. food, fuel, linen, stationery), medical supplies (eg. bandages, sutures, chemicals, endotracheal tubes), and some equipment replacement. Some equipment running costs were hidden in general 'administration' budgets, others (site preparation, training for maintainers) were without budgets. Routinely, recurrent budgets were cut heavily in all three countries.

For many years, consultants have encouraged health service providers and external support agencies to always purchase the package of inputs required and not simply the equipment itself, but progress is slow. The cost implications of the package can be significant. *Berg* explains that even from non-profit oriented bulk purchasers: surface transport and insurance can be 30 to 40% of catalogue price, for larger equipment special installation needs and some user training can be 80% of catalogue price, and if airfreight is used shipment might even exceed catalogue prices.[245] However, the implications of not purchasing the package are also costly.

A new exercise is required within health facilities where departments specifically gather data on the usage rates and requirements for equipment consumables, accessories, spare parts, and other inputs; and incorporate the information into any existing Health Management Information System so that recurrent budgets for equipment-related consumables can be based on real needs. This is another example of *Witter et al's* proposal that cost information is a vital managerial tool.[230]

8.4 FINANCIAL PLANNING AND CONTROL

8.4.1 Financial Planning

In order to avoid the wastage of the cyclical approach to funding (Figure 2.8), health services need expenditure plans that estimate annual requirements over a period long enough to achieve rationalization – perhaps ten years.[3] The previous sections demonstrate that the countries studied undertook limited financial planning for equipment, and many new equipment needs were covered by donor-funded projects. Some finance officers simply based their budget submissions on the previous year's expenditure. As this was sorely lacking, it proved to be a poor basis for planning. An extreme example was the Primary Health Care Services division in Botswana. Table 8.7 shows that it spent only US$ 1,750 (3,700 Pula) on medical and surgical equipment from its recurrent vote during the whole NDP6 period (1985 – 1991). This was meant to cover the replacement needs of all primary hospitals, as well as primary care clinics in district hospitals.

Resources must be allocated to cover the life-time cost of equipment, including purchase, installation, operation, maintenance, and training. One initiative offered by *Temple-Bird* is a process for formulating a Core Equipment Expenditure Plan which estimates the cost of providing all health facilities with a basic level of healthcare technology over a set period (such as 5 or 10 years).[75] As a result of the research analysis, by 2000 the Planning Directorate of the Namibian MOHSS started such a process and were drafting their first five-year equipment purchase and costing plan (*MOHSS & Temple-Bird*).[178,246] This work was pertinent to the re-structuring process underway. With planned decentralization of services, the MOHSS were determining the new service delivery structure and goals, and developing 'essential service packages' – a common activity in developing countries currently. Although multi-disciplinary teams were involved, the small pool of junior technical staff had little input. The Deputy Director of Planning voiced concerns that the process concentrated too much on medical interventions and their staffing implications, whilst the packages could already be seen to be unaffordable in equipment hardware and life-time cost terms. The calculations shown in this Chapter illustrate that the MOHSS was not affording to sustain the equipment it already owned, let alone some increased stock level.

In all three countries it was apparent that when new purchases were planned under development budgets, the necessary parallel increase in recurrent funds to run the new equipment was not reflected in recurrent budgets. For example, Botswana had substantial health development projects (Section 8.1.2), but by 1992 the Ministry of Finance had not prepared projections of recurrent funds required to keep the new facilities and equipment running for DABS, DEMS or MEMS. In addition, money for equipment-related training was rarely linked to capital expenditure plans.

It appears all too easy for health service providers to concentrate on development expenditure, especially as this is supported by donor projects and funds. It is a major management failing of both ministries (Health, Works, and Finance) and donors to disregard the link between planned capital expenditure and the resources required to keep the new items going.

8.4.2 Financial Control

Zambia and Botswana were examples of highly centralized systems. Health facilities did not control their own budgets for equipment or its recurrent costs; the budget holders were a complex array of central bodies that mainly did not keep data on expenditure by facility. The facility management teams interviewed complained of little influence on how funds were used for equipment. Such centralized financial control systems created serious administrative difficulties.

Ironically where decentralization had taken place, these problems did not go away – if anything they got worse. Namibia was an example of a country which had decentralized the most. A wide range of staff, from levels that should have been assessing their annual equipment needs and planning expenditure, admitted having no technical skills and limited financial management skills. Decentralization had introduced an unwieldy "economizing process" where committees met at each level (facility, district, region, centre) to judge if a maintenance job, for example, was a priority and affordable before a request was passed up the line, a quote accepted, or money allocated.

Some decentralization of budgetary control is useful; health facilities need to make plans according to their own financial strategies. However, in certain instances it may be beneficial to control a budget centrally especially if funds are short or there is insufficient management capability at the decentralized level. For example, *Temple-Bird* found that the Ghanaian MOH had decentralized funds prematurely for PPM – an essential activity to ensure the safety and continued functioning of equipment. With limited technical understanding and skills, district authority personnel were randomly suspending PPM whenever funds were short. Thus the MOH found it better, with a shortage of technical staff, to pool its resources and run PPM from a central workshop and a centralized budget; this ensured that PPM took place as a priority activity nationwide.[247]

8.5 CONCLUSION

Halbwachs asserts that healthcare technology management not only contributes significantly to the economy of healthcare delivery but also to assuring the quality of diagnosis, therapy, and safety. Therefore, healthcare technology management is a core function in healthcare delivery and should be a core part of health financing.[248] But resource constraints are a feature of developing economies, thus this Chapter proceeds with my third theoretical perspective and continues a *Development* approach by studying the allocation and management of finances for equipment in the public health services of the three countries studied. Although cost information is a vital managerial tool, it was not readily available for the analysis of the equipment sector. This was true of both the Ministry of Health and the Ministry of Works (MOW), which often financed the plant and service supplies requirements but did not even have budgets broken down by client ministry. There were limited, if any, specific equipment expenditure records, inventories, or stock values; thus figures had to be extrapolated and calculated during the field research to produce the original data presented here. These activities proved useful as, in some instances, they prompted the MOH to start to use such analytical tools, and ensured that I always employed them during subsequent work.

The analysis in this Chapter describes situations which illustrate and introduce further major development issues:

i. short-term viewpoints instead of sustainability of investment;
ii. decentralization leading to a duplication of scarce resources, and unsustainable increase in costs;
iii. top-level agreement on strategic plans and their implementation;
iv. how to finance all parts of the cost iceberg.

Capital expenditure on equipment usually fell under development votes, and was often financed by large donor projects (Section 10.3). Often this was the method used to procure substantial quantities of equipment needs for new facilities or upgrading projects. However, that left the remaining facilities and normal yearly depreciation of equipment unaccounted for. Using international guidelines, the average replacement cost required each year is 10% of stock value. The analysis shows that the ministries of health allocated on average 1% or less – leaving a disastrous backlog of old and broken equipment. Both the MOH and MOW were facing bulk replacement requirements that no one was offering to finance. Even with the obvious benefit of having equipment in working order, the recurrent budgeting for maintenance and repair was woefully poor, and fluctuated a great deal. Rather than the international guideline 6% of stock value for medical equipment maintenance, ministries allocated on average 1% or less. Other equipment life-time expenses for consumables, training, transport, site preparation, etc., could not be identified as the expenditure records were insufficiently detailed. Without records for analysis, none of these items were planned on the basis of real requirements or usage rates. Thus, no rational equipment expenditure planning was taking place in the MOH or MOW, and their needs were not being integrated into the Ministry of Finances's plans for the health service.

This situation is an example of the first major development issue – a short-term response compromising the sustainability of investment. Although the ministries of health had different stock levels, the analysis found that they would require around US$ 5-10 million per year to cover regular equipment replacement needs (for medical equipment and some hospital furniture and plant). Depending on the percentage of GDP allocated to health (Table 5.10), this would have used anything from 2.6% (Namibia), 9.1% (Botswana), to 21% (Zambia) of the total health budget. In addition, they required US$ 2-5 million per year to cover the maintenance needs for their equipment. This would have used anything from 1.7% (Namibia), 8.3% (Botswana), to 13% (Zambia) of the recurrent health budget. They also required substantial amounts for life-time costs; these are unknown but can be a significant proportion of, and even exceed, the procurement costs.

The degree of decentralization of health services that had been introduced, was one source of problems with financial control. If the system was too centrally controlled, facilities could exercise no responsibility or influence over equipment affairs, but without widespread technical skills or general management skills (Chapter 7), decentralization of financial control for equipment proved premature and important tasks were randomly abandoned when money was short. These examples introduce the second major development issue of inappropriate decentralization.

Many ministries of health are currently undergoing (donor-supported) restructuring plans. One element is to shift expenditure towards more consideration for primary care. Observers say that there is too much emphasis on spending for tertiary (and even secondary) facilities, however it should be recognized that these buildings and their equipment are a vital part of the referral system that serves the primary level. Another element is development of essential service packages, which also incline towards decentralization of service delivery. The real danger is that the packages developed are unrealistic in equipment terms. Although decentralization is seen as politically correct for equity of access (ie. closeness of access), the multiplication of the equipment stock involved cannot be afforded. Health service providers will have to recognize the need to shift the balance of different elements within their budgets; for example why increase the wages bill, if there is insufficient equipment and maintenance resources to enable clinical staff to do their jobs? This situation leads to the third major development issue – the need for top-level strategic planning both in health service organizations and in external support agencies (Chapter 9). As *Pfeiff* proposes, the acceptance of technical staff and technological tasks depends on the value placed on technology.[103]

One important question is how to finance the requirements. It is recognized that health service providers in developing countries have other pressing needs on their finances, such as malaria, childhood diseases, HIV/AIDS, etc. They are also going through many changes, such as health sector reform, and it is difficult to know which strategies will work. As in other parts of Africa, *Watkins'* study of Zimbabwe found that structural adjustment initiatives have proved unsatisfactory. When the government introduced fees, attendance dropped significantly, the poor were excluded from basic services, and there was a failure to run a viable exemption system.[249] Zimbabwe found the projected gains to be wildly exaggerated; most district-level facilities were unable to raise more than 2% of their budgets through the cost-recovery route.

Halbwachs asks "in light of the fact that around 50% of public health funds are used by hospitals, one may wonder why neither governments nor donors have not directed more attention to maximising the useful life of physical health resources, in particular buildings, equipment, and vehicles?"[248] Is it because key decision makers are doctors, administrators, and health economists, rather than people with a technical viewpoint? It is important for ministries to investigate the cost effectiveness of different equipment strategies, ie. improved maintenance versus premature replacement, high versus low technology, contracted maintenance versus in-house teams, cheap initial purchase price versus life-time expenses, capital investment for replacement versus down time of services, duplication of services versus high usage rates. Perhaps cost-benefit analysis of equipment activities would act as sufficient proof for decision-makers to allocate adequate funds for them? For example, *Halbwachs* presents the case for readjusting the maintenance system to spend more time on PPM, rather than undertaking repairs purely in reaction to breakdowns.[198] Such issues highlight the need to finance all parts of the cost iceberg, and introduce the fourth major development issue. The role of public, private, and donor organizations in this task are pursued further in Chapters 9 and 10.

In answer to my question "*can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?*", I have shown that there have been a number of small successes and larger initiatives whose outcome is still unknown:

* rethinking of budget layouts and accounting methods to reflect equipment expenditures (ie. Namibian MOHSS plans);
* equipment inventories and stock value calculations (ie. Botswanan and Namibian MOH);
* mandatory 10% of budget allocations for health facilities and authorities (net salaries) to be set aside for maintenance (ie. Zambian MOH); [however, this dictated percentage is not a measure of the likelihood of sustaining the equipment stock, is still too low, and hides the true extent of the under funding of maintenance activities];
* sale of government property not in use and residential property not in remote locations, to finance the maintenance of government buildings (ie. Namibian MOWTC);
* retention of central control for organizing and financing some key equipment activities, such as PPM (ie. Ghanaian MOH).

In addition, there are a number of potentially useful initiatives which as yet have not been sufficiently pursued:

* breaking down the MOW's budget by client ministry and preferably by facility;
* ensuring all equipment procured (by health service provider and external support agencies) includes the 'package' of inputs;
* calculating usage rates for equipment consumables and spare parts so that realistic recurrent budgets can be set;
* developing a Core Technology Expenditure Plan for the long-term (ie. Namibian MOHSS plans), which is integrated into the MOF plan for the health service;
* placing as much emphasis on supporting healthcare technology management initiatives in ministries of Works as in ministries of Health.

Experts now ask the donor community to assist countries to develop adequate equipment management systems and contribute to recurrent equipment expenditures. The role of private sector support and public/private partnerships for strengthening technical management capabilities regionally and nationally also need to be investigated. Thus Chapter 9 examines private sector support capacity and Chapter 10 examines the role of external support agencies, both of which inform this financial discussion, the *Development* approach, and additional major development issues.

CHAPTER NINE: TECHNICAL SUPPORT AVAILABLE FROM THE PRIVATE SECTOR

When taking a *Technological Systems* approach in Chapter 5, I identified the technical support available from the private sector as one of five fundamental overarching themes key for sustainability of the healthcare technology sector. A country's private sector support capability is dependent on the national economy, industry, and technical capacity, as well as regional resources, and therefore is clearly a development indicator. Thus this Chapter continues to take a *Development* approach – my third perspective, and provides further examples of major development issues concentrating on public/private collaboration.

This Chapter describes the outcome of the country case studies into the nature, capacity, and performance of the private sector (both locally and internationally) in support of healthcare technology. Two aspects of private sector involvement are studied – their manufacture of suitable equipment, and role in providing the HTP sub-systems. It presents the results of interviews made with private sector companies (Section 3.3), constraints identified, and assistance obtained from literature on trade influences and technological transfer, development and management. It continues to look for examples of innovations which would provide answers to my fourth research question:-

Q4 *Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?*

9.1 STATE OF THE PRIVATE SECTOR IN THE THREE COUNTRIES STUDIED

In Zambia the manufacturing sector was small and healthcare technology was no exception. Virtually no healthcare equipment was manufactured locally (except exercise bicycles and prostheses), and most medical supplies and consumables had to be imported. Even with vast areas of forest, simple wooden tongue depressors still had to be imported. Government health officials reported negotiations with a donor for the local manufacture of syringes, but it is unclear what happened to this initiative following the International Monetary Fund (IMF)-led withdrawal of donor support (see Section 10.3). *Temple-Bird* reports one useful initiative started by the local Association of Physiotherapists which organized the local production of physiotherapy and occupational therapy exercise aids; as these products often only require skills in wood-work, sewing, and manipulation of locally available materials, the physiotherapists undertook the work themselves or contracted local craftspeople.[200]

Only a handful of companies were active in the sale or maintenance of healthcare equipment. Some firms operated in near-monopoly conditions but, when interviewed

(Section 3.3), reported difficulties in remaining viable because of depressed market conditions, weak infrastructure, under-developed industrial base, problems in obtaining foreign exchange, spare parts, and payment from government. The MOH only had nationwide maintenance contracts with three companies each covering a different equipment category (x-ray machines, lifts, piped gas and anaesthetic machines), and contracts with two additional firms (for laundry and kitchen equipment) covering parts of the country. Two other companies acted as suppliers of equipment only, with no maintenance capability. The firms ranged from state-owned monopolies such as ZAMOX (Zambian-owned former branch of the British Oxygen Company) that provided all oxygen products, to small two-man concerns such as former employees of the General Electric Company (Zambian subsidiary) who repaired x-ray machines.

In 1992, Botswana's industrial and private sectors were small and newly established, and had only recently become involved in healthcare equipment. A handful of companies were active in the sale of such equipment, only two provided maintenance services (Section 9.3), with few actually manufacturing products. Absence of foreign exchange restrictions, ease of importation, and availability of parts from South Africa should have created a climate conducive to local private sector development, but there was limited manufacturing for the health sector. Compared to its neighbour Zimbabwe, Botswana had perhaps not been pressured into finding local manufacturing alternatives since there were no restrictions on foreign exchange and importation of goods, and traded with South Africa throughout the apartheid boycott period.

Liquid Air Botswana supplied all medical gases in cylinders to the health service. The manager explained that it produced medical oxygen in Botswana, but all other gases and associated gauges, meters, pipework, etc, were manufactured in South Africa. A number of companies manufactured wooden furniture for domestic use and educational facilities. A whole range of simple metal hospital furniture was produced in neighbouring countries like Zimbabwe.[250] But it was unclear whether such products were purchased by the MOH.

There were a few initiatives to locally manufacture health products. I visited two local companies that manufactured wheelchairs designed as suited for local terrain and needs, and a simple upholstered adjustable dental chair. The orthopaedic workshop of the central referral hospital manufactured and fitted orthopaedic aids and appliances for clients. Some prostheses were made entirely in Botswana, others such as knee joints were assembled from imported parts, as were microscopes. Firms found other items cheaper to import from South Africa (SA). MOH officials admitted that they had not held discussions with local firms about suitable designs and support for local production, or investigated regional suppliers of more 'appropriate' products; such strategies were not pursued in the following decade either.[177]

Within Namibia's small manufacturing sector, the production of goods for the health service was mainly limited to medical supplies, or the assembly of equipment rather than actual manufacture. The research found that in 1997, only approximately 5% of medical equipment was manufactured in Namibia, and comprised low technology items such as developer tanks and monitor shelves. AFROX (Namibian-owned former branch of the British Oxygen Company) had a plant for producing oxygen, and a factory existed for intravenous-fluid production; these products were exported to neighbouring countries. Beds and hospital trolleys were assembled locally from parts made either in SA or overseas.

Private sector companies stated there was more scope to manufacture consumables locally, but a problem with the small market for them in Namibia. Although items could be exported regionally, local consumption was the important factor and Central Medical Stores' projected requirements were too vague. They spoke of past initiatives to buy materials and manufacture consumables and low technology items, only to receive no orders from the Ministry of Health and Social Services thus making a loss. They could not foresee the production of high technology equipment items in Namibia **in their life times.**

MOHSS officials reported making efforts to support local production for regional supply (ie. basic x-ray equipment for the Southern African Development Community region), wanted to support more by standardizing to local products, collaborating on design and production, and bulk buying of equipment and spare parts, but found it difficult due to a weak industry for the size of the market, and restrictive tender board regulations. The private sector reported to me that the capacity for change and expansion within the industrial sector was limited by the following factors:

* the small Namibian market;
* larger competitors (ie. South African companies) lowering their prices to kill Namibian initiatives;
* government not being able to protect small local enterprises, nor the Tender Board give them preference, because of South African Custom Union rules;
* the local labour force being expensive and unreliable, making local manufacture of specialized goods in small quantities not viable.

A study of relevant literature illuminates the issues surrounding the situation in the case study countries. *Halbwachs* notes a growing potential of alternative manufacturers in newly industrialized countries, such as Argentina, Brazil, and Mexico, which produce some medical equipment suitable for rough conditions. He proposes that, except for catastrophes, the donation or importation of low technology items should be avoided. Instead local production should be stimulated, creating labour opportunities and promoting self-sufficiency.[244]

Observers recognize that before local production can be economically viable, a stable market for healthcare products must be established This will depend on: assured funding for health services (Section 8.2); allocation of adequate funds for maintenance and spare parts (Section 8.3); a reduction in the number of brands serving the local market; and progress in regional integration. Governments may have to standardize to locally manufactured products if they want to support local industry, create a stable market, and protect against foreign competition. *Wilson* states the debate is about the balance between supporting "infant learning" (by protecting local, fledgling manufacturing industry from foreign competition) and encouraging competition and export orientation.[251] He reports that most observers agree that some form of institutional support is very important in order to master new technologies. The OECD, for example, acknowledges that "personnel, policies, institutions, and culture through which technologies can be created or transferred and disseminated are largely missing in the Third World".[251]

Stewart explains the different approach required when importing goods and services rather than technologies. i) A local capital goods sector is necessary for local technological development, and local product innovation flourishes more often behind protective barriers since local technology may not be internationally competitive initially. Export orientation puts such emphasis on market success that entrepreneurs cannot afford to experiment with local technology and tend to take product design from their main developed country markets. Conversely, the pressure of international competition can lead to process innovation (reduced costs, greater labour-intensity) or motivate firms to innovate or adapt their products to local conditions. ii) When importing technologies, it is important to remember that local technological capacity is an infant industry requiring protection initially. Obviously all technology imports cannot be kept out, since each country would then have to re-invent everything. What is required is a selective policy towards the import of foreign technology, determined by the type of local technology to be promoted. One option is to take a strong appropriate technology orientation, exclude most advanced capital-intensive technology and inappropriate products, and import only technology which will help develop a level of local appropriate technology. Another option is to import foreign technology in order to adapt it to local conditions and to learn how to produce it; in this case technology is only imported if it cannot be produced locally, and then only imported once (a method used by Japan, South Korea, and China). A final option is to let any restrictions on importing advanced technologies be mild and take second place to the aim of mastering the technology (the method used by India).[252]

Lall proposes that a firm's scope for efficient specialization in technological activities, their ability to extend and deepen these with experience and effort and draw selectively on others to complement their own capabilities, is the hallmark of a "technologically mature" firm. But since full 'maturity' has not been achieved in the typical firm in developing countries (with deficient skills and limited experience), it is likely that it will use the same technology less efficiently than its counterpart in developed countries.[226] *Niosi et al* warn that transferring manufacturing technology from abroad will not be without costs: for acquisition of proprietary technology owned either by the transferor, or a third party supplying disembodied know-how; for R&D to adapt technology from industrial countries due to different raw materials, market scales, or available inputs (skilled labour, equipment, etc.); for transmission, ie. the transferor may be obliged to codify and make explicit some aspects of the technology that are part of 'common knowledge' of the advanced country industry; and for learning (training) for the developing country partner.[253]

However, *Stewart* suggests that indigenous technical change can be facilitated through a number of economy-wide policies covering:-

i) Incentives – not necessarily financial, but to increase the acceptability of locally designed products by disallowing foreign brands, limiting advertising, and reducing the market power of foreign technology.

ii) Mechanisms for technology transfer – the more packaged the transfer (eg. using subsidiaries of multi-national corporations) the less government control and the more foreign technology used. Thus governments can encourage local capacity to work with 'unpackaged' elements of a transfer, and negotiate with MNCs to promote and use local technology and not inhibit its development (through prohibitive patents and copyright clauses).

iii) Macroeconomic policy – technology change and learning is more likely in an environment of continuous industrial expansion, thus government actions are required which actively promote rather than depress industrial activity.

iv) Local linkages – a major inducement for technological change comes from demands imposed by one firm on its suppliers, and is lost if these suppliers are foreign (another reason for protective practices). Industries with strong natural local linkages will incur greater technological changes than those (such as assembly plants) where most inputs are imported.

v) Monopoly/oligopoly versus competition – due to economies of scale in production and the need to protect local products, large-scale and oligopolistic firms may best promote local technological change, but have less incentive to innovate. Large firms, producing foreign-designed products, tend to innovate on the basis of changes imported from abroad and are less likely to be appropriate than small firms. By contrast, local products of small firms may have more to offer, but are disadvantaged by small-scale production and difficulties of competing with foreign-designed products.[252]

These recommendations provide hope that developing countries can develop products appropriate to their needs, especially if governments support strategies to stimulate indigenous technical capacity. Unfortunately, current moves by the World Trade Organization to limit protectionism and open all markets to 'free trade' would imply that such initiatives would be discouraged if not actively banned. In addition, multi- and bi-lateral funding agencies working in the healthcare sector, such as the World Bank, oppose countries' attempts at standardizing their technology imports if not in word then through their strict procurement policies and regulations (Section 10.5). Thus, developed nations have a profound influence on local attempts to manage the healthcare technology sector (see Section 9.4).

9.2 MAJOR SOURCES OF THE HEALTHCARE TECHNOLOGY PACKAGE

Table 9.1 shows that the total world sales in medical equipment in 1985 was US$ 30 billion, with the majority market being the US and Europe.[35] *Issakov* reported the total world market for medical equipment and supplies (excluding pharmaceuticals) had risen to US$ 71 billion by 1991.[5] However, his figures were not broken down by product groups or region. Similarly, it is not possible to estimate current world sales since the trade statistics consulted only record cross-border sales (exports and imports) and not in-country sales.[34,44]

TABLE 9.1[1] : World[2] market[3] in medical equipment, 1985[4]

Product group	Sales (US $ bn)			
	US	Europe	Rest of world	Total
Laboratory diagnostics	2.50	1.25	1.25	5.00
Imaging	2.75	1.25	1.00	5.00
Other electro-medical	2.75	1.25	1.00	5.00
Single-use	6.50	3.00	2.50	12.00
Specialties	1.50	0.75	0.75	3.00
Total	**16.00**	**7.50[5]**	**6.50**	**30.00**

1. Savory Milln Ltd estimates, quoted in Cabinet Office, Advisory Council for Applied Research and Development, Medical Equipment, HMSO, London, 1986 [35]
2. The countries included were not listed, but a number of socialist economies were included.
3. This includes cross-border sales (exports and imports) as well as in-country sales.
4. Later statistics do not show in-country as well as cross-border sales, nor present trade by these product groups
5. UK market was estimated to be around 4 per cent.

Source: Bloom G.H., and C.L. Temple-Bird, 1988, Medical Equipment in Sub-Saharan Africa: A Framework for Policy Formulation, IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7 [3]

As discussed in Section 2.3.5, world trade in this field has been dominated by Germany, the US, and Japan, but the UK, France, Italy and the Netherlands have retained a significant share of the world market in the last decade and a half.[32-34,42-44] The major suppliers of both medical instruments and electro-medical equipment to SSA, reflecting to a large extent the region's colonial past, were France, the UK, and Germany (Figures 2.9 & 2.10). More recently, Italy, the US, the Netherlands, and Japan were increasing their sales to Africa as a whole (Figure 2.11).[3,44]

The possibilities for international private sector support to all component sub-systems of the HTP system is vast. Equipment is sold by manufacturers, suppliers/wholesalers, and packaging/ procurement agents (selling and shipping a package of items to equip a whole health unit). Turnkey operators are packaging/procurement agents who also install and commission the goods and handover a working unit. Package/turnkey consultants assist with preparing designs and plans, writing specifications, selecting goods, evaluating tenders, etc; supervisory consultants act on the customer's behalf to monitor activities of others (ie. installation and commissioning by manufacturers' representatives). Some maintenance contractors work on behalf of a range of manufacturers; more rarely others are contracted by governments to maintain all equipment types. Public and private sector health institutions 'twin' with a developing country or facility to provide advice, information, personnel, technical support, etc. Public and private training centres offer a variety of courses.[3]

Zambia's equipment reflected the sales monopolies of local agents of international firms, for example the majority of x-ray products came from GEC (UK), and oxygen, anaesthesia, and theatre-related products from the British Oxygen Company. In the public sector, I found evidence of new kitchen and laundry equipment manufactured in South Africa suitable for local conditions. The mines had recently purchased sophisticated dental suites from Germany. Most equipment was influenced by the donor programmes financing them, ie. Eastern European products under Czechoslovakian aid and Japanese products under Japanese International Cooperation Agency (JICA) support (Section 10.3). From my experience, it is advisable to buy healthcare technology direct from the manufacturer (to avoid 'middlemen' mark-up), or from their local representative if technical support is required in future (financed by a percentage of the sales). However as the economic crisis deepened, local middlemen played an essential role. With the public sector lacking funds to pay up-front for goods and foreign currency, private sector firms agreed to buy goods from abroad and allow hospitals to repay in local currency over time (although many firms went bankrupt waiting for payment).[171]

Botswana used a small number of foreign organizations to assist with providing the HTP sub-systems, including: manufacturers, suppliers, packaging/turnkey agents, consultants, maintenance contractors, and training institutions. I surveyed a large selection of these companies and the outcome is presented in Table 9.2. Of the 63 companies involved, 17 were based in Botswana, 29 in South Africa, the remainder were European, and one Indian. Many of the Botswanan companies simply acted as sales representatives for imported

TABLE 9.2: Identifiable sources of supply to the Ministry of Health, Botswana 1992[1]

Country company based in	Total	Manufacturers	Subsidiaries[2]	Suppliers of items made by others	Turnkey operators solely	Maintenance companies	Offer support[3]	Consultants
Botswana	17	2	1	10	1	2	1	-
Sth.Africa	29	4	5	17	-	2	1	-
UK	8	3	-	3	-	-	-	2
Belgium	1	1	-	-	-	-	-	-
Denmark	1	-	-	-	1	-	-	-
France	1	-	-	-	1	-	-	-
Germany	1	1	-	-	-	-	-	-
Holland	1	-	-	-	1	-	-	-
India	1	1	-	-	-	-	-	-
Ireland	1	-	-	-	-	-	-	1
Sweden	1	1	-	-	-	-	-	-
Switzerland	1	-	-	1	-	-	-	-
Total	63	13	6	31	4	4	2	3

Notes:
1. From a questionnaire sent to all equipment supply companies on the Department of Supply's list of tenderers for the MOH, feedback from facilities & MOH staff, & company interviews (see Section 3.3.2).
2. Subsidiaries are branches of international companies and therefore may either sell items made by sister companies or may manufacture equipment on site.
3. Companies providing support to the MOH by locating maintenance sources, locating spares, by transporting goods to and from repair, etc.

products. As government procured for hospital upgrades, undue donor influence on equipment sourcing should have been avoided. But the projects were greatly influenced by turnkey consultants (one British, one French), and problems arose of unsuitable products.[71]

The research shows that although the number of Namibian companies selling to the medical sector was increasing gradually, 95% of healthcare technology was imported. Approximately 80% of these imports came from South Africa, of which 80% SA imported from overseas and the remainder they manufactured themselves. Thus only approximately 15% of healthcare technology was imported into Namibia direct from overseas.[73]

Officials interviewed reported that around 90% of all high-technology medical equipment originated from well-known companies in Germany, UK, US or Finland. Medium-high technology equipment (suction pumps, infusion pumps, operating tables, etc) was often manufactured in South Africa. 70% of medium and low technology equipment, instruments, and hospital furniture was imported from the Southern African region and 30% from overseas. Namibian producers supplied certain household and office furniture items or very low technology medical equipment.

The MOHSS had developed a strong Planning Unit with capabilities in facility design, specification-writing, etc. that had begun to use technical management consultancy support for the HTP system (Section 6.1.3). They had introduced a good initiative whereby the vast majority of products were based on one- or two- year supply contracts with firms, in order to introduce some standardization and consistency (Section 7.3).[204-206] Another excellent initiative was the insistence on local maintenance capability as a condition for awarding a supply contract, with the frequency and terms for providing maintenance and repair negotiated depending on equipment type.[74] The MOHSS used around 25 different suppliers. But as many international companies had made South African companies their selling agent/representative for Southern Africa, this forced Namibia to buy through SA.

The literature review showed that many observers recognized a shortage of information easily-accessible by developing countries that details sources of technical support available. With limited access to international data on manufacturers' products, equipment choice is often solely based on the type of items staff were exposed to when trained. *Müller* suggests that weakness of healthcare technology support in Sub-Saharan African countries, means regional centres of support are required to provide information and advice (but not maintenance).[254] *Lee* proposes regional libraries dedicated to holding specific user and servicing documentation and training materials, in a format accessible to health sector workshop staff.[225]

9.3 THE ROLE OF MANUFACTURERS & THEIR REPRESENTATIVES

My earlier research into the export of medical equipment to SSA included interviews with 19 UK manufacturers and 13 UK support companies that operated there (one-third of total relevant firms).[255] This made it possible to determine the different types of representatives used by manufacturers, and their role in SSA, as shown in Table 9.3. Although a number of approaches are available to exporters for providing crucial after-sales support in more affluent countries, their developing country customers are not served nearly so well. When interviewed, many reported having no representatives at all, and those with representatives admitted that they did not provide the full range of services (marketing, stocking spare parts, providing technical advice, and undertaking maintenance). They attributed this to a number of factors:-

- Difficulty in identifying suitable firms to be representatives, with customers in SSA providing little feedback on performance of representatives.
- Shortages of foreign exchange limiting the capacity of representatives to import or hold equipment and spare parts.
- Health service providers not budgeting adequately for maintenance, making it not a viable business proposition (especially in rural areas).
- Conflict between purchasing equipment at as low a price as possible by a method (such as package or turnkey arrangements) that bypass commissions and exclusivity percentages, or making such payments to representatives so they can create a basis for providing on-going maintenance services.
- Servicing not providing sufficient business for local representatives to interest them in training their staff.
- The important role of representatives in maintaining communication between manufacturer, client, and government departments (covering: customs, tenders, transport, licensing, finance, importation, warehousing, etc) being hampered by the complex administrative and legal environment.

During the economic boom in Zambia in the '70s, subsidiaries and agents had maintained items such as x-ray machines, sophisticated laboratory equipment, monitors, piped gas supplies, lifts, and laundry equipment. However by 1990 the numbers of representatives operating in Zambia had fallen to only a handful. As the MOH budget became more constrained, fewer maintenance contracts were being signed with the private sector (Section 9.1.2) with very few offering regular servicing of equipment.

The quality and cost of maintenance services from private companies varied considerably. Maintenance staff informed me of some with a fairly good reputation, but others that charged excessively. There were complaints about slow response times, long delays in

TABLE 9.3: **Types of representatives used by equipment manufacturers and their role in SSA**

Type of representative	Relation to manufacturer	Sales	Support	Role in SSA
Subsidiaries	Branch of parent company, subject to direction from head office	Able to supply all of manufacturer's goods	Can offer full after-sales support (in theory) using own & parent company's resources	Very few exist; mainly used by multi-nationals.
Agents	Formal contractual link with manufacturer to cover a specific territory; strong ties & a high level of commitment between both parties.	Either able to supply all the manufacturer's goods, or only those especially directed at the market in their territory.	Should be able to supply strong after-sales support, but often covering a wide geographical territory.	Although manufacturers have agents in Europe, US, Middle East, etc, very few used this term for their representatives in SSA, preferring 'distributor' (see below).
Distributors:	* Independent companies which import & distribute equipment. May undertake some manufacturing themselves, should have experience in importing, the health sector, & preferably a service/workshop capacity. * Many deal in equipment from a wide variety of manufacturers & do not have loyalty to any one of them. * The manufacturer-distributor relationship varies, with many receiving a commission (a defined percentage of the selling price) to cover, in part, the cost of meeting after-sales commitments. Some arrangements include exclusivity agreements whereby the manufacturer commits to selling its products through a 'sole distributor' in a country, if any goods bypass this distributor (ie. through a package purchase process) they are still entitled (in theory) to receive a commission. * Three broad categories of distributor were described, varying on the range & quality of service offered & the resources that the distributor is prepared to invest. The type chosen by a manufacturer often relates to the complexity of the equipment supplied:-			
Type 'A' distributors	Receive commissions & have exclusivity agreements. In return, the manufacturer expects an after-sales service to be provided	Sell the manufacturer's goods. Should install, commission, & carry out user training (when necessary).	Most substantial commitment to servicing of the distributor types. They cover cost of after-sales & maintenance commitments, staff & run a workshop, stock specified parts, send staff to manufacturer for training.	Fairly common, but only if suitable local firms can be found. Used by manufacturers whose relatively sophisticated products require installation by qualified staff.
Type 'B' distributors	Receive commissions but no exclusivity agreements. Manufacturers report little control over the quality or comprehensiveness of the service provided.	Sell the manufacturer's goods. Install only on request, may at the same time do commissioning & user training.	More modest commitment to servicing. They stock some spare parts, staff & run a workshop, cover after-sales during warranty, send staff to manufacturer for training (costs shared).	Also common, with some firms having multiple arrangements like this, but a lower spread across SSA. Mainly used by manufacturers of medium-tech equipment.
Type 'C' distributors	Act predominantly as selling outlets. The manufacturer can only cajole them to carry out after-sales tasks, but they are not required to do this.	Sell the manufacturer's goods. Usually don't install, commission, or train users.	Some form of servicing may be provided. The manufacturer offers advice & tries to convince them to hold spares, train their staff, & offer some support.	Quite common, mainly as sales outlets. Used by producers of low-tech equipment, or items not requiring installation.
Informal contacts	No formal arrangement, but contacts with whom the manufacturer is in regular communication.	Act as an entry point into a new market, identify new sales opportunities, may help with importation.	May be contacted by a manufacturer with no local rep. who needs a firm to sort out a problem with its equipment.	Occasionally used, mainly when manufacturers are trying to do business in a country that uses a different language.

repairing equipment, low levels of technical expertise, poor quality workmanship, and so on. Many companies in turn complained about late payment of accounts and unreliability of the MOH as a customer. During a donor-funded equipment-purchasing phase in the 1990s, I observed that although foreign manufacturers chose local firms to be their representatives, public sector technical staff knew that most would be useless since they lacked workshops or technical personnel, but were powerless to nominate more useful firms.[171]

In Botswana, I reviewed the resources available to the MOH from tendering companies and local firms. The analysis in Table 9.4 shows that suppliers had limited their possible support to Botswana by not establishing local maintenance workshops, but could offer technical input from bases in neighbouring countries. However in 1992, the MOH had only one annual maintenance contract, and requested annual services only occasionally. The analysis in Table 9.5 shows that training could also be offered; once again the MOH had not taken up these opportunities.[71] One MOH initiative was to use local firms as technical 'facilitators', that sourced maintenance support and spare parts, and transported goods for repair to overcome customs and shipment problems.

The MOHSS in Namibia had maintenance contracts with local firms for high technology equipment only. These firms were mainly small outposts of the South African distributors and either used their own technical personnel or support from SA.

The analysis shows that the absence of adequate back-up from manufacturers has created difficulties for the users of equipment in SSA. As *Halbwachs* states, we should be able to assume that manufacturers and suppliers would have a genuine interest in assisting their customers in the selection process and in logistical questions, but in developing countries this is mostly not the case. There, suppliers are usually not encouraged to do more than make a sale. In addition, a lack of serious and competent competition does not stimulate after-sales service. He also states that donor organizations often do not possess specialist healthcare technology know-how and, for selection and supply, they seek advice from the eager supplier. But the suppliers in industrialized countries cannot sufficiently appreciate needs and conditions in developing countries, and it is common therefore for the equipment reaching such countries to fail the required, yet often undefined, standards.[244]

The analysis also shows that local representatives do not have a role in the manufacturing process of the product. This is a failing *Lall* reports, because the developing country affiliate, with few exceptions, receives the results of innovation and not the innovative process itself. Manufacturers do not find it efficient to invest in skill and linkage creation in a new location. The affiliate, in consequence, develops efficient capabilities up to a certain level, but not beyond: known in the literature as "truncation" of technology transfer. Such truncation can:

TABLE 9.4: Maintenance Resources available from Suppliers[1] to the MOH, Botswana in 1992

Country Company Based In	No.	No. with Local Rep & Location[2]	No. of local Maint. Workshops & Location[2]	AFTER SALES SUPPORT: During Warranty: Available[4] as Standard	AFTER SALES SUPPORT: During Warranty: Only On Request	AFTER SALES SUPPORT: After Warranty: Available[4] as Standard	AFTER SALES SUPPORT: After Warranty: Only On Request	REPAIRS & SERVICE CONTRACTS: Available[4] as Standard	REPAIRS & SERVICE CONTRACTS: Could be Arranged
Botswana	8	N/A	5 in Bots 3 None	5	3	3	5	4	4
Sth.Africa	13	12 in SA 1 in Bots	13 in SA[3]	11	2	10	3	13	-
UK	4	3 in SA 1 in Zim	2 in SA 1 in Zim 1 None	4	-	2	2	3	1
Denmark	1	1 in SA	1 None	-	1	-	1	-	1
Holland	1	1 in Zim	1 in Zim	1	-	-	1	1	-
Sweden	1	1 in Zim	1 in Zim	1	-	1	-	1	-
Switzerland	1	1 in Zim	1 in Zim	1	-	1	-	-	1
Total	**29**	**21**	**27**	**23**	**6**	**17**	**12**	**22**	**7**

Notes:
1. Information from firms who replied to questionnaires & those interviewed.
2. Bots = Botswana; SA = South Africa; Zim = Zimbabwe
3. Six of these firms had more than1 maintenance workshop in South Africa
4. Available as standard practice, but MOH made no use of these services.

TABLE 9.5: Training Resources available from Suppliers to the MOH, Botswana in 1992[1]

Country Company Based In	No.	User Training			Maintenance Training		
		Available[2] as Standard	Only On Request	None[3] Available	Available[2] as Standard	Only On Request	None[3] Available
Botswana	8	2	5	1	1	3	4
Sth. Africa	13	9	2	2	6	3	4
UK	4	3	1	-	2	2	-
Denmark	1	-	1	-	-	1	-
Holland	1	-	1	-	-	1	-
Sweden	1	1	-	-	1	-	-
Switzerland	1	-	1	-	-	1	-
Total	**29**	**15**	**11**	**3**	**10**	**11**	**8**

Notes:
1. Training was sometimes available in Botswana, in a neighbouring country, or in the country of origin of the equipment.
2. Training available as standard practice, either at regular times or by arrangement with the customer - but MOH had not asked for it.
3. Often suppliers did not offer training themselves, but some could arrange with the manufacturer for training - only if the customer asked them to.

- diminish the affiliate's own technological development;
- diminish its linkages with the host country's technological and production infrastructure;
- limit any subsequent beneficial interaction with these sectors;
- prevent the affiliate from investing in their own capabilities;
- and, when times get tough, may lead them to withdraw from the activity altogether.[226]

It would appear that there is potential for the private sector to expand its role in healthcare equipment, if business were more dependable. Nevertheless, with so few companies and little competition, excessive reliance on them may leave governments vulnerable to poor service and high prices.

The research found examples of small initiatives in the region, just starting to be used or discussed, that I used in my subsequent work. For instance, some health authorities compile local technical and environmental data for inclusion in their bidding/quotation documents, so that suppliers can identify appropriate products to offer.[171,177] Health authorities have been called on to identify local firms with suitable skills and resources to act as local representatives, and to find some way of communicating this information to manufacturers.[202] Some companies are trying to offer technologies suited to the region and to support them there.[171] *Müller* calls for healthcare technology support to be provided on a regional basis since individual countries do not have the 'critical mass' to get a service going.[254]

Back in 1988, *Bloom & Temple-Bird* suggested various more technological systems-based ways in which manufacturers could develop a long-term presence in developing countries. They could establish holistic relationships either with local private firms or directly with the public sector.[3] A considerable amount of work is still needed to see such agreements and relationships implemented effectively in developing countries, especially as both the product market and government maintenance budgets are so small. They would need to be based on rationalizing equipment services, providing securer markets for products, and introducing new ways to provide low cost technical support.

9.4 THE INFLUENCE OF DEVELOPED NATIONS

Since most healthcare technology has not been developed specifically for use in developing countries, much of it is not appropriate for that environment. As Section 2.3.5 explained, *Lechat* and *Jordan* put forward ten criteria to be used in assessing whether equipment is appropriate, relating to its application, sustainability, and suitability to the local environment and community.[47,48]

Banta reported that there have been many developments in health technology over decades, but little work yet on evaluating possible applications in developing countries.[124] International firms reportedly are unwilling to undertake the necessary development of products designed for conditions in developing countries. For most manufacturers, the hospitals of Europe, North America, and Japan are their principal customers and development work is focused on maintaining a share in a highly competitive market. This requires that they keep up with (or ahead of) the rapid evolution of models incorporating the latest innovations. They do not feel that there is a secure market nor economic incentive to invest significant resources in R&D for appropriate technology.[3] However, this might change if adequately funded Core Equipment Expenditure Plans were implemented, as recommended in Section 8.4.

Appropriate types of equipment are difficult to find on the market. I discovered that this was due to a number of factors:-

i) Product development in developed nations has embraced microprocessor and computer technologies, thereby making all machines more sophisticated. Formerly, in developing countries most electro-mechanical machines could be repaired by local electricians, mechanics, and plumbers. Problems immediately arose when microprocessors or computer programmes were introduced into relatively basic machines (eg. bench-top autoclaves, centrifuges). Microprocessors and computer programmes fail frequently leading to, for example, a machine to stop with its door locked, then not only can traditional technicians not correct such faults, but also the users cannot retrieve the contents of the machine.

ii) The direction of development in the industrialized developed nations has responded to or even brought about modes of employment that encourage labour reduction and automated processes. This is at odds with the requirements of developing countries who are labour rich and resource poor. For example, South African companies produced sturdy electro-mechanical industrial laundry machines suited to the continent that had basic controls, could be maintained by local technicians, and were used in laundries which employed a variety of staff to load and unload the washers, dryers, and ironers.

iii) The pressure of such strong international product lines and the preference of donors to purchase, if not their own products, then at least products they know, has led to many 'alternative' producers going out of business.

iv) Methods of working in developing countries are often different to those in developed ones, thus different types of equipment are required which may be out of fashion elsewhere. For example modern laboratory equipment is designed for bulk analysis and manipulation of vast quantities of samples, whereas the throughput is much smaller in developing country facilities and calls for smaller machines.[171]

A stricture on both the manufacture and use of appropriate equipment in SSA is the profusion of international operational standards and regulations, promulgated by developed nations on the way work should be undertaken. It is becoming increasingly difficult to conform to many of these requirements, as they can be inappropriate or inapplicable to prevailing conditions in developing countries. Many are based on assumptions that do not stand up. From my experience such standards often assume different working practices to those found in developing countries, and can set the wrong goals if pursued. For example, international regulatory benchmarks for operating theatres assume sterility is achieved through the developed-nation model of an enclosed space with an artificially-created environment, providing negative pressure air-flow over the operating table. Often developing countries have theatres with windows open to the dust and air, this does not mean that many patients die of sepsis, on the contrary local staff have adapted their way of working to local conditions. Attempts to reach such a gold standard will be technologically complex, and costly to achieve and sustain. In Zambia, I found many basic anaesthetic machines without modern operational safety features, however local anaesthetists knew the limitations of their equipment and adapted how they worked. Modern replacement models are too expensive, so the old units will simply continue to be used. Thus it was more pragmatic to take the cheaper route of using South African skills to update the existing models, even though this was frowned upon by the funding agency.[171] Alternative, more appropriate, standards may be required for the region, or it may be necessary to aim for the international standards but achieve them only in a realistic step-by-step fashion. As an engineer, however, I stress that an important exception is the international manufacturing safety regulation for electrical medical equipment (International Electrotechnical Commission standard 60101), otherwise lethal items appear in the marketplace (eg. from China, India, and even the UK).[71,247]

Due to their perceived need to emulate developed-nation operational standards, South African firms have recently changed the face of their manufacturing. This appears to be driven by: their wish to be part of the international export market rather than a regional market; and their desire, after long years of isolation, to be seen as an equal player with developed nations. Thus, a great opportunity for SA manufacturers to be a valuable source of appropriate products for the region is being lost.

The research found that attitudes of developed nations affect technology transfer. *Dahlman et al* state that some foreign partners and suppliers will do much more than others in transferring their technology to developing countries, and the older the technology the more willing the supplier is to share information. How generous they are will depend on their motives; a supplier who is abandoning a product line will include much more in a technological transfer than a supplier continuing with a product line. The nationality of the supplier also makes a difference; for technologies required for many basic industries the

Europeans can be more generous, whereas for many consumer goods the Americans can be more generous.[256] *Chanaron & Perrin* explain that the common practice for transferring research, development, and design (R,D&D) to developing countries is to follow a mechanical or 'steps of stairs' model. This is based on the idea that every product development and design is incremental, thus the transfer will involve progressive appropriation from the simplest step (a single modification of a product) to the most complicated ones (an entirely new process or product), and each step will have its own pre-set labour organization, personnel and skills levels, requirements and training needs. Thus the transferee's ability to move from one step to the next is determined not only by his increased competence, but also by a process of negotiation with the transferor. This philosophy is becoming increasingly unacceptable to many developing nations. However, there is an alternative route for transferring R,D&D using an organic or 'amoebic' model. This requires the transfer to contain, either in seed or fully developed form, every function, task, skill, and internal or external link necessary for various phases of product development. Any organization is seen as a system with all necessary elements present, that will grow in size and competence. The acquisition of know-how must thus be targeted at collective institutional know-how and training, which incorporates all technical levels and tasks. Such a philosophy for technology transfer is preferred as it develops organizational and learning processes within the recipient firm – a strategy proposed in Chapter 6.[257]

9.5 OTHER SOURCES OF SUPPORT

Dahlman et al looked at the management of technological development in newly industrialized countries to find the lessons for firms and governments in developing countries. One important factor was the economic environment, which influenced the technological efforts of firms and thereby determined the productivity of a country's resources. They felt that national environments were shaped by the activities of specialized technological agents that provide technological information, means, and understanding (such as engineering firms, intermediate-goods producers, machinery producers, research institutes, information centres).[256] In the three countries studied, I discovered that a mix of public and private organizations were successfully maintaining equipment, although facing the same environment and restrictions as the health service, and could offer support as technological agents.

The Zambian University's Department of Veterinary Medicine developed a maintenance workshop, with JICA assistance for equipment and training. It was able to repair a wide range of the laboratory equipment common to Zambia. *Temple-Bird* found that it had offered to assist the Evelyn Hone Paramedical Training College by repairing and maintaining the equipment used on the laboratory, pharmacy and environmental health training courses. The charges for this service would be used to source spare parts abroad and develop its workshop.[200] The mining health sector had considerable maintenance and training capabilities (Section 7.5.2), but I found no formal link with public sector hospitals and only ad hoc support in 1990. Ironically the selling off or closure of many mine hospitals in the subsequent decade (Section 6.1.1), and the closure of Zambian Airways released skilled technical personnel onto the market place which public sector hospitals could employ, finances and authority permitting.[171]

The Botswana Technology Centre was a non-profit organization, funded by government and reporting to the Ministry of Finance & Development Planning. It aimed to promote interest in technology, assist nationals to identify appropriate technology choices, and use local resources and knowledge to evaluate and adapt new technologies that would meet the need and challenges specific to Botswana's economic development. They had a technology development division, technology information service, and technology assessment unit.[258] When interviewed, senior staff stated that it could meet this remit due to its funding and ability to hire enough engineers and technicians to fill departments for: electronics, civil engineering and architecture, systems and testing, computer systems, renewable energy, and mechanical engineering. Its aim was R&D and a number of its designs were for the health sector (eg. rechargeable hearing aids using solar photocells), but it had been unable to assist the MOH with its requests for medical equipment repairs. However they were calibrating clinical function testers for the health service, and electronic instruments and test equipment for MOH's workshops.[71]

Data Processing (Pty) Limited in Gaborone sold and serviced electronic equipment such as computers, printers and peripherals. They provided service contracts to their customers (including the MOH), and delivered a professional service. The managing director told me they had been able to develop such technical capabilities due to:

* sufficient and suitable work space for electronic repairs, with correct tools;
* sufficient numbers of skilled maintenance staff adequately remunerated;
* ability to obtain spares from abroad easily, together with an adequate stock;
* training programmes for staff.

In Namibia, I found several local technical consultancy firms which the MOHSS had used to study and report on facility designs, laundry services, undertaking inventories, etc.[178] In all three countries the research or support role of engineering departments of higher education facilities have, in general, not been pursued.

The analysis shows that the number of technological agents available was low. *Davis et al* report that science and improved technology should be playing important roles in the development of Africa. But, most African countries are ill-prepared to assimilate exogenous technology and improve indigenous technology. Only a small handful of countries have been able to develop active national scientific and technical (S&T) communities; for many sustaining S&T institutions has become a difficult burden with competing demands on limited resources; economic stagnation puts severe pressure on existing fragile S&T infrastructures; and in many the viability of scientific research and education is threatened. Extensive emigration of scientific and engineering personnel from Africa to Europe, North America, and Latin America is one of the legacies of stalled industrialization in Africa. They feel that even if structural adjustment programmes are successfully implemented (which supposedly enable the development of private business and entrepreneurs), the public sector will remain a key actor in the scientific, technological, and economic life of African countries for the foreseeable future.[259]

9.6 CONCLUSION

The management of imported technologies requires a combination of skills, such as capacity to: select equipment from a wide variety of sources, negotiate with suppliers and monitor their performance, plan and manage the use of the technology, and maintain it at as low a cost as possible. In developed economies, such skills are widely distributed in a large number of firms, research and training institutions, and public sector bodies. This is not the case in countries of SSA. As *Bloom & Temple-Bird* stressed, the smallness of the industrial sector means that an organization using imported technology must develop all the necessary skills itself, or to identify sources for the specialized inputs.[260] The constraints imposed by the overall smallness of the industrial sector in SSA are compounded by the small size of most national economies. *UNIDO* identified the limited size of national markets as a serious constraint to industrial growth.[56] It has made it difficult for organizations to develop specialized capacities.

The private sector has two roles to play – manufacture of suitable healthcare technology, and involvement in delivering the HTP sub-systems. The analysis in this Chapter describes situations which illustrate and introduce further major development issues:-

i. conflict between elements of protectionism to promote local technological capacity, and international pressure for free-trade often encouraged by structural adjustment programmes;
ii. influence of international private sector companies on developing countries, in terms of their unwillingness to commit to appropriate R&D and to after-sales support of their products;
iii. public/private collaboration to promote local technological capabilities in industry;
iv. an increase in regional integration (for SSA) and the development of regional policies;
v. public/private collaboration in order to provide for all parts of the cost iceberg (see Section 8.5).

The three countries studied had small industrial sectors in general, and very small healthcare technology sectors which mainly concentrated on sales and support rather than manufacturing. There was a need for locally manufactured products, and observers agreed that such fledging products would need a guaranteed market and protection from developed-nation designs and export orientation. However regulations of bodies, such as the World Trade Organization, make the standardization and protectionist initiatives required impossible – the first major development issue.

The traditional sources of equipment to Zambia, Botswana, and Namibia reflected their colonial past, or the donor who funded the purchase. A new development is the concentration of manufacturers' distributors in South Africa nominated to cover the whole of southern Africa, thereby forcing other nations to purchase and import via South Africa. Manufacturers sell to developing countries whether they can offer after-sales support or not, and if they do the service is inferior to that offered to developed nations. They have little incentive to act differently – the second major development issue.

Product design and development is not aimed at or appropriate for developing country markets. Donors promote these developed-nation products through their funding and procurement rules, which lean towards the cheapest product rather than applying value judgements on the appropriateness and sustainability of a product. It is increasingly difficult to find appropriate designs more suited to local technical skills or the different work practices in developing countries. Potential local manufacturers (such as those in South Africa) are being pressured to conform to international standards that have been written without taking developing country realities into account. Developed nations dictate the type and method of technology transfer, which can restrict progress with local technological development. Developing country governments will need to take firmer control over these processes and negotiations if they are to succeed in managing their imported technology.

The skills required to provide different components of the HTP system are available in a number of public and private sector institutions, many of which are not directly involved in health activities. The analysis found that limited use was made of organizations to assist with these other elements of the HTP system, and there was a shortage of information regionally for sourcing such support. Examples could be found of various technological agents, that form a part of the national support environment. But in general the science and technical communities in Africa are facing the same technology constraints as the health service, and observers stress that nations will need to pay more attention to technology management. *Niosi et al* studied the success of technology transfer to developing countries by Canadian consulting engineering firms. Success in technology transfer could not be assumed; although over 50% of the transferees had acquired some capabilities, only a few were very able or perfectly able to independently execute the activities that were transferred. Less than 40% of the transferees were able to execute projects of a similar nature, even if the project was not the first in a specific area.[253]

The analysis demonstrates that a great deal of work is required by government to support indigenous technical change through a number of economy-wide policies, and by manufacturers to invest in skill and linkage creation in their affiliates so as not to truncate technology transfer. These are examples of the need for public/private collaboration in order to promote local technological capabilities – the third major development issue. The analysis shows that, indigenous industrial technological capability development will also require both an *Institutional Organization* approach in order to obtain learning organizations (see Chapters 6 and 7), and a *Technological Systems* approach in order to unpackage and transfer the HTP system (see Chapters 4 and 5). Thus all parts of my Thesis Framework are of relevance when studying the role of the private sector.

In answer to my question *"can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?"*, I have demonstrated that a few initiatives exist, but only relate to local manufacturing and servicing sub-systems of the HTP, as follows:

- local manufacture of physiotherapy and occupational therapy exercise aids, wheelchairs, etc, the assembly of products from imported parts, and a number of South African products made with the needs of the region in mind;
- 1-2 year supply contracts, with local maintenance capabilities as a condition of contract;
- support available from other sectors, such as a technology centre, a University department, middlemen and facilitator firms.

In addition, there was evidence of some initiatives that have potential for the future if the health authorities pursued them:

- providing suppliers with details of local technical and environmental conditions;
- identification of local firms which would be suitable local representatives;
- development of national equipment expenditure plans (Section 8.4) to create a stable market for after-sales support;
- regional centres of technical information, advice, and possibly maintenance support.

For each stage in the HTP system, the strategy for making good use of available resources and developing local capacities should be based on a good understanding of the resources available in the public sector, the rest of the national economy, the region, and supplier countries. The use of my modelling framework (Section 4.2) as a tool in three case study countries (Section 3.3) provided such valuable information, which was original.

The problems of importing healthcare technology (Chapters 5 – 8) are not unique, are not likely to be solved solely within the health sector, and are the same as those connected with the import of any new technology. Thus it would appear that the solutions should be similar. Policy-makers will need to be able to assess the local capacity to undertake each element of the technology transfer process, in order to select a realistic strategy. One response to these issues, advocated by the *Economic Commission for Africa*, would be to increase regional integration and develop regional policies – the fourth major development issue.[261] For this to happen, close liaison is required between the client ministry (ie. the MOH) and ministries for areas such as trade, industry, finance, and development (see Table 6.5). For SSA, the present and future role of South Africa may well be key; it appears to have a dual influence – positive and negative. The analysis shows that due to its technological strengths, it is a source of technical support and locally manufactured equipment, and has great potential to specifically design and produce equipment appropriate to the needs of the region. However, its commercial strength and competition can put neighbouring country manufacturing out of business, and its drive to meet international export standards may push it away from local needs.

Efforts should be made to integrate initiatives taken in the healthcare technology sector with the broader process of developing an industrial sector. Healthcare technology constitutes only a small proportion of imports to the region. Nonetheless, I propose that efforts to strengthen equipment services could contribute to the development of local technical capacities. The selection, installation, use, and maintenance of equipment requires substantial skills. A well-managed service can, therefore, become a source of experienced technicians to the industrial sector. Planned equipment services (nationally and regionally), ensure a regular demand for specialized services, spare parts and replacement units. This can create a stable, if small, financial base for the gradual upgrading of local technical skills. An element of standardization (limiting the range of makes and models) for imported equipment, is more likely to produce a stable market and encourage local representatives offering after-sales support. Such initiatives are a better basis for health service providers to develop new relationships with manufacturers, private sector companies, and donor agencies, and examples of the fifth major development issue – the public/private collaboration required to provide all parts of the cost iceberg (Figure 8.1).

In the longer term, it might be possible to undertake an increasing proportion of the HTP system at national or regional level. This could lead to increasing capacities to manufacture spare parts and common equipment, and undertake technology assessment and research. Increased HTP system capabilities would also significantly enhance the *Institutional Organization* and *Technological System* capabilities required to improve technology transfer of imported equipment. Thus one consideration in developing strategies for managing the equipment services should be its contribution to increasing technological capacity in the region.

Dahlman et al state that the technological policies of many developing countries reveal the perception that technology is singular and that it must be either imported or created at home. But technology is not singular, for it consists of technological information, technological means, and technological understanding. Thus the question is not whether to import technology or create it at home, but which elements to import and which to obtain from domestic sources. The appropriate choice between foreign and domestic sources depends on an evaluation of associated benefits and costs, using processes that properly reflect relative scarcities and identify the source that yields the highest net benefit. Most discussion about the acquisition of foreign technology focuses on how the technology is transferred, rather than on what technological elements are being transferred and why they are being acquired overseas.[256] In addition, the option chosen will affect the rapidity of transfer, degree of knowledge and understanding gained locally, and amount of control the developing country obtains. Options include: direct foreign investment in a wholly owned subsidiary or in a joint venture with local participation; licensing; turnkey projects; purchases of capital goods; and purchases of technical assistance. The route taken is often dictated by the external support agency funding the transfer. Such agencies have a great influence on the importation of healthcare technology into developing countries. Therefore, Chapter 10 will continue this discussion and the *Development* approach by looking at the role of external support agencies.

CHAPTER TEN: THE ROLE OF EXTERNAL SUPPORT AGENCIES

When taking the *Technological Systems* approach in Chapter 5, I identified the role of external support agencies as being one of five fundamental overarching themes key to the sustainability of the healthcare technology sector. The role, intervention, and power of external support agencies are a feature of being a developing country. Thus, this Chapter continues to take a *Development* approach – the third theoretical perspective of the Thesis. Following on from Chapters 7 – 9, it introduces further examples that highlight major development issues.

This Chapter describes the outcome of the country case studies into the nature of the role played by external support agencies in support of healthcare technology. It presents the successes, constraints, and problems found, and looks for assistance from aid and development literature. It continues to provide examples of innovations which would provide answers to my fourth research question:-

Q4 Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?

10.1 THE NATURE OF DONOR SUPPORT FOR HEALTHCARE TECHNOLOGY

The term 'external support agencies' covers various bodies such as: international donors; technical agencies of foreign governments; non-governmental organizations (NGOs) and individuals; and financial institutions; all of whom provide financial and material support to health service providers and their programmes. Such bodies may run projects to support the development of healthcare technology.

TABLE 10.1: Different categories of aid

	Multi-lateral aid	Bi-lateral aid	Non-governmental
Implementors	International organizations, such as the World Bank	Governments through aid agencies, such as USAID or GTZ	Religious, humanitarian, and charity groups and individuals
Funding	Contributions of member states	Tax money, to some extent donations	Donations
Target groups	Predominantly governmental organizations	Mixture of governmental organizations and population groups	Predominantly population groups and local non-governmental organizations

Table 10.1 shows the range of categories of aid described by *Halbwachs*, a long-term GTZ expert in healthcare technology aid programmes. He states that all three categories may either concentrate on purely financial or commodity aid, others (such as GTZ) on technical co-operation, or on a mixture of both forms. Technical co-operation combines a number of aid instruments, dominated by the provision of short and long term (technical) advisors and training of counterpart staff. Other instruments are the provision of infrastructure, development centred research, and direct financial contributions. Depending on the aid organization, the financial control may be in the hands of the partner or the implementing agency itself. In addition, a special field is emergency aid.[262]

Much equipment, and especially second-hand equipment, gets into developing countries through activities that are labelled charitable. *Halbwachs* describes three main groups involved in these activities. First, are well-meaning organizations with a professional and appropriate approach, typically the classic religious mission organizations. They try to provide relevant training, spare parts, and consumables to sustain equipment, but invariably introduce makes and standards from their own country. Second, are well-meaning but inexperienced groups which overlook essentials such as health priorities, qualifications of users, technical environment, and financial resources of the recipients. Symptomatic of this group are the spontaneous donations from or through individuals. By this method, many health facilities in developing countries are being furnished with machines that do not work because there is no electricity, or with eye-glasses for which individual adaptation is not possible because no ophthalmologist is available. The third and smallest group consists mostly of small firms or agents who consider themselves well-meaning but are motivated by profit. For example, they collect obsolete equipment from private practices and hospitals and sell it to charitable organizations, or gain tax advantages for their clients by exporting these inappropriate goods as donations.[244]

GTZ has found container loads full of technical garbage in some African countries declared, for example, as fully functional hospital furniture.[244] The *International Medical Device Group* reported that at the start of the '90s, 40 tons of used equipment was donated by US hospitals and airlifted to the Ukraine, where virtually all of it proved to be unusable.[263] Whilst working in Bosnia during the war (1993 – 96), I came across many examples of misguided charitable support for healthcare technology.[264] Agencies and individuals wanting to support the health facilities, started well-meaning collections from their own hospitals, but supplied shipments of useless items.[265]

Halbwachs states that international donors have been an important source of finance for equipment purchases in many developing countries, and estimates that roughly 70% is being provided by external sources.[244] The most common is bi-lateral aid and particularly organizations which offer technical co-operation, then multi-lateral aid, and charitable organizations (ie. NGOs, churches, gifts from individuals). More than a dozen multi-lateral organizations, several dozen bi-lateral agencies, and hundreds if not thousands of non-governmental organizations provide this aid.[262] The problem of, and the need for, sensible co-ordination of all these groups at national and international level is evident, but has rarely happened. My work in Zimbabwe provided a simple example, one NGO supported a village with a work-creation and income-generation project and provided tools, materials and training for local people to produce metal buckets, baths, dishes, etc. A different NGO arrived in a neighbouring village to support a clean water and community hygiene project, supplied the villagers with plastic buckets, baths, bowls, etc., and immediately undercut the business base of the first project.[250]

The type of support offered by external support agencies continually changes according to the current development fashion. In the 1970s, the trend was for tertiary and secondary care and support was given to building hospitals. Equipment was generally provided as part of projects aimed at expanding health service infrastructure. During the decade after the *WHO's* 1978 Alma Ata Declaration, considerable effort and resources were placed in establishing primary healthcare programmes, training health workers, and expanding health infrastructure to that end.[46] Thus the 1980s saw the donor fashion change to the building and equipping of clinics and moving away from supplying equipment to hospitals.

Subsequent evaluation of their equipping programmes by the donor community, found that within a few years many facilities could not provide the intended services.[20,237,266-274] These failures were due to poor selection of technology, inadequate recurrent funding, and difficulties in operation and maintenance, all of which have been the subject of much of this Thesis. Often the problem boiled down to the donor's focus on a single project, with little regard for the environment within which it hoped a useful service could be sustained. As Section 2.3.10 explained, attempts to improve the situation had been piecemeal with projects that only addressed a part of the problem (eg. training technicians without improving their workshops). In the absence, of broader sectoral initiatives that considered the equipment situation as a 'whole' and addressed the problems of establishing sustainable equipment management, these measures were not very successful.

Thus, in the '80s the time was ripe for developing countries to see maintenance of healthcare technology as a sector worth developing. The *WHO* has been a driving force in this process, producing a global action plan to promote modern maintenance and repair concepts, which later developed into policy issues for healthcare technology management.[1] The 1990s saw the start of good initiatives with individual donor projects that were more holistic in their support of the equipment sector. As *Temple-Bird et al* reported FINNIDA undertook a project in Nicaragua to renovate and equip a network of maintenance workshops, provide tools and PPM materials, develop equipment operation and maintenance systems, train staff in their use, rehabilitate key equipment, provide spare parts, strengthen the national equipment management team, and support local manufacture of key parts and simple equipment.[275] *GTZ* started a series of projects and would, over many years, prove to be the most effective in this field. They developed 2- and 3-year training courses for maintenance staff in various countries, established local or national maintenance structures, and provided technical experts; they later expanded into the establishment of equipment management systems and structures within decentralized health authorities, as well as support for the creation of the African Federation for Technology in Healthcare as a professional peer-group body for technical staff in Africa.[217] These are examples of what I have conceptualized as a *Technological Systems* approach.

But in the main, major initiatives were not pursued which would rationalise a country's equipment service and its management. In general, the '90s saw the support for primary care interventions continue, with many donors moving away from any substantial support for hardware (health facilities and their equipment), even though funds for new and replacement equipment were desperately required (Section 8.2). In the hospital construction projects that did take place, attempts were made to take some of the new ideas into account, by including a maintenance workshop in a hospital design, for example. Also in this period, training opportunities were reduced by donors (see Section 10.7).

Halbwachs reports that in the past, mostly the ever-ready donor stepped in and replaced physical assets. In recent years the donor community has become increasingly hesitant and has begun instead to ask the partner to take care of maintenance of physical assets, and leaves him alone with this problem. Most developing countries are not in a position to deal with this situation without external technical and financial assistance.[243]

In the late '90s and early 2000s, much development work in the health sector concentrated on shifting authority to decentralized bodies, increasing autonomy for facilities, strengthening management skills, and policy development work. In a parallel field, *Wield* studied donor support to universities in Africa. He found that donor support has assumed a great overall significance and is increasingly needed for core activities, is often planned in relation to policies developed by each separate donor agency, thus generally is not integrated into institutional development initiatives. Not only does this erode capacity-building, but also increased reporting requirements, which differ from donor to donor, are extremely burdensome and do not necessarily improve managerial effectiveness.[276] The prevalence and mode of operation of donors in the health field is similar. Thus new concepts are gaining recognition for the coordination of the numerous and diverse donors. These include Sector Investment Programmes (SIP) and the Sector Wide Approach (SWAP), where the public health service providers in developing countries are supposed to be in the 'driver's seat' negotiating and establishing an umbrella of health programmes to which all donors contribute in a harmonized manner. But, this will only be of use for developing the healthcare technology sector, if it moves up the priority list (Section 10.9).

10.2 HOW DONORS FUNCTION

The characteristics of donor support affect the healthcare technology sector in developing countries. Also, the disbursement of funds is subject to the rules and administrative procedures of the organisations involved, and these policies and practices influence the development of the equipment service.

10.2.1 Slowness of Disbursing Aid

In 1987, *Pearson* stated that for many years aid agencies had deplored the long delays that seem endemic in the disbursement of project aid. During the 1980s the emphasis tended to move from development projects to rehabilitation and reconstruction programmes. The World Bank was originally the pre-eminent institution endorsing this change in emphasis, but the effectiveness of its programmes was reduced by insisting on linking them to internal policy reforms. However sound these may have been technically, they invariably presented the governments concerned with difficult political problems that took time to resolve. In this way, much of the necessary speed in implementation required to prevent further economic deterioration, was lost.[277] This aspect of aid affected the healthcare technology sector (Section 10.3).

10.2.2 Negotiation Channels

External support agencies usually liaise with a specific government department in developing countries, that is responsible for aid negotiations; something like a National Commission for Development Planning that usually falls under the Ministry of Finance. Unfortunately these bodies often undertake minimal collaboration with the relevant ministry let alone the target health facility, have limited expertise relevant to each project area (such as healthcare technology), but none the less draw up and sign detailed contracts. For example, in the late '90s the Ministry of Finance in Ghana drew up contracts with a variety of different financiers from different countries to support the upgrading of ten regional hospitals. Technical personnel from the MOH were not involved in developing project details that would ensure implementation could be rationalized, or in specifying equipment details; the contracts did not include a package of inputs for equipment; and the MOH were not given a role in monitoring the contracts. The contracts enabled the financiers to independently use different consulting firms from various European countries, thus each hospital upgrade was treated as a separate isolated project and there was no coordination of technology levels, equipment types, or equipment sources. The consulting firms were able to take control of procurement processes, excluding the Ghanaians (at least for the first few hospitals) from involvement in the equipment specifications, packages of inputs, etc. The heads of the hospitals concerned were not consulted or involved in the decision-making about the facility they would have to run. The end result was complex, sophisticated, very expensive hospital upgrades – hardly surprising as the consulting firms were to receive a percentage of the building price; it was reported that the hospitals would cost more than if they had been built in central London.[278]

10.2.3 Use of Competitive International Tenders

Section 2.3.6 highlighted the problem of competitive international tenders being the required mode of procurement. During my original research into this field, I interviewed firms involved in the export of healthcare technology to SSA.[3,255] They reported that existing tender procedures present a number of difficulties indicative of wider problems in the procurement process:

* lack of experience in writing specifications and tenders means inadequate information is provided to bidders;
* the tender document format, designed to provide no preferential bias, does not allow bidders to explain pertinent features of their product/offer, biasing the process in favour of the lowest cost bid;
* poor understanding of equipment means tenders frequently omit the 'package' of inputs, if a bidder includes them his price will not be competitive, but if he quotes for them separately such an addition to the bid is unacceptable;
* inadequately skilled adjudicators cannot compare the relative merits of bids, so tenders are usually decided on the basis of cost;
* bid preparation time is short (leaving no time for clarification), but the process of adjudication, clarifying contracts, making financial arrangements, etc., can take up to a year, and this delay is reflected in the price;
* significant effort is invested in preparing each bid, the chance of any one succeeding is small, so this cost is reflected in the price. For tenders where delays are common and significant amounts of paperwork required (ie. multi-lateral organizations like the World Bank), the mark-up can be 20%. To save money, clerical staff may draw up the bid, and are less likely to detect problems in the tender request.

The use of international competitive tenders, therefore, creates difficulties for the rationalization of the equipment sector. This is especially the case where attempts to standardize equipment or screen manufacturers are considered as restrictive practices by international funding agencies, and consideration of quality issues and other factors (such as availability of after-sales service) are inadmissible unless they are in the original specifications. The only consideration is whether a product meets the specifications, after which the cheapest is chosen. For these reasons, *Barraclough* asks whether such donor procurement rules are suitable for buying complex equipment, and if the art of obtaining the right equipment is choosing the right donor (and hence the right procurement method).[279]

10.2.4 Tied Aid

Several donors do not tie aid, but others require that suppliers from their country be given preference. An extreme example I experienced was the Chinese development of a sports stadium in Zimbabwe, when all the construction machinery and tools (bulldozers, shovels, etc) were brought from China even though Zimbabwe had a thriving building industry, firms supplying heavy machinery, as well as manufacturers and a thriving local market for basic tools. The Chinese went so far as to bring cement and bricks with them from China, although Zimbabwe had many cement and brick production facilities.[250]

In Zambia, JICA supported the building and equipping of UTH's new Paediatric Department in the late '80s. They selected Japanese equipment and even service reticulation materials (eg. water pipes) that were not always compatible with existing consumables or attachments. Although three years of spares were included together with technical assistance (one maintenance technician), by 1990 this was coming to an end and problems had begun to arise concerning future provision. Another difficulty was that instruction and service manuals were mostly in Japanese.[69]

Tied aid in general means that a country ends up with a wide variety of different makes and models of equipment and cannot rationalize its stocks; all three countries studied contained a wide variety of donated equipment. Supposedly donors have been changing this policy, but it depends on the donor and is taking a long time. In 1988, British procurement and packaging agents reported that they were permitted to use non-British goods only when none were available in the UK. *Haddon & Temple-Bird* reported that by 1996/7, DFID was still trying to tie its aid to Zambia by using an 80% rule; 80% of goods had to be made in or supplied from the UK.[280] During an equipment supply project there I, as the equipment consultant, had to make a special case for there to be an exception and waiver to this rule. Luckily the UK's Department of Trade and Industry was willing to do this, and the project avoided inappropriate British products which had no local after sales support.[171]

The tying of aid should not be unexpected, as the Finns candidly explained in a booklet describing their development cooperation:

> "Purchasing the goods and services needed for development co-operation from Finland both increases contacts between Finland and developing countries, and *reduces the inevitable negative effects of development co-operation on our balance of payments*"(my emphasis).[281]

10.2.5 Focus of Development Work

A number of donors internally produced evidence of being aware of the problem of non-functioning equipment, but the research found that even those with projects to support the equipment sector paid little attention to this topic in their official publications.[282-4] Most donors working in the health sector are staffed by a variety of clinical professionals, administrators, and economists, but not in-house engineers with healthcare technology skills. Up to 1997 the (then) ODA's guide to working overseas contained a list of skills needed: they specifically named engineers but not for healthcare technology, managers but not for technology, health and population professionals but not technical staff, and health buildings staff but only hospital managers.[285] As *Halbwachs* explains a donor organization is mostly and primarily an administrative body and often does not possess its own specialist know-how sufficiently. This know-how, in the case of healthcare equipment selection and supply, is often sought from the supplier which, as Chapter 9 shows, is not always appropriate.[244] The danger of relying on external temporary consultants or running activities as independent projects means that there is institutional memory loss of hard-won knowledge (*Adler & Cole*).[189] Section 6.2.1 also shows that, for healthcare technology, external support agencies do not have the organizational design recommended by *Berggren* which will support learning.[180]

Engineering within the health sector is obviously not seen by existing donor staff as a prime concern or a major development issue, and as *Cohen & Levinthal* warned by not developing absorptive capacity in this field, donors risk being 'locked-out' of further technological understanding (Section 6.2.3).[179] DFID, for example, has found it difficult to know which division or programmes healthcare technology issues should fall under. In 2000, it tried to remedy this by launching a new Knowledge and Research programme on Disability and Healthcare Technology, so that projects could be sponsored which support, amongst other things, the development and application of healthcare technologies for developing countries.[286] This initiative may go some way to preventing them from becoming locked-out.

10.3 SUPPORT TO THE THREE COUNTRIES STUDIED

In Zambia the 1970s saw the last construction of new government hospitals – University Teaching Hospital in Lusaka, and Ndola Central Hospital, as well as Czechoslovakian support for the central National Maintenance Workshop. In the following 20 years, there were only a few initiatives to equip hospitals from donors, or government due to severe limitations with MOH's capital funding (Section 8.2). In the late 1980s, there was support from: JICA for the development of UTH's Paediatric Ward; Belgium for mission hospitals; the Swedish International Development Agency for rural health centre expansion; and WHO for various programmes such as immunization. This support included a variety of funds, equipment, and technical assistance.[160]

During the 1990 study, no major plans for substantial equipment purchases by the MOH could be found even though the equipment was in a deplorable state (Section 5.1.1). Only a few donor assisted projects were under discussion that might have involved healthcare technology. The Government of the Republic of Zambia (GRZ) was having co-ordinated discussions with the World Bank and other donors for health initiatives to alleviate the 'social dimensions of structural adjustment'.[287] It put forward a variety of projects involving substantial equipping and rehabilitation of health facilities, but the donors did not want to concentrate on these longer-term development initiatives and preferred to address the immediate health problems effecting those most vulnerable to structural adjustment.[288]

The 1990 country study was a consultancy assignment (Section 3.3.1), and *Haddon, Temple-Bird, & Bloom* recommended to the MOH and ODA that the GRZ seek external support to undertake a major re-equipping programme for their hospitals, because equipment was dangerously below minimum standards necessary to maintain adequate health services. In addition, a comprehensive process for building up equipment management skills within the health service was required. To this end conversations began with the donors active in Zambia for a coordinated approach.[69] Unfortunately, all these initiatives were cancelled following an IMF-led withdrawal of donor support when GRZ withdrew from structural adjustment programme terms. When interest and money resumed 3 – 4 years later, I estimated that only 5 – 10% of the equipment stock could be rehabilitated due to its subsequent ageing.[171] DFID funded a much-reduced programme, aimed at three hospitals only, with limited capital funds for equipment which meant the project frustratingly could only nibble at the edges of the problem. Although developing management skills at these hospitals was a good initiative, *Temple-Bird* reported little functioning equipment to manage, and no linkage to or support for a national healthcare technology management capacity.[232]

In Botswana, up to 1992 several funding agencies and donor organizations provided support to the MOH, covering 71% of the costs of a wide range of development projects.[289,290] The large hospital upgrading programmes used substantial amounts of both government and external funding, and included supply of equipment. The research found that influence was exerted by the external agencies providing the finance, and the consulting and turnkey firms contracted to assist with the upgrading. A significant project was NORAD assistance to strengthen the Medical Equipment and Maintenance Services.[291]

For Namibia, Table 10.2 summarises the main donor agencies that supported the MOHSS' equipment sector in the five years prior to the 1997 study. FINNIDA and the European

Union (EU) also provided management support to the ministry. However, most of Namibia's development work was financed by the government. The MOHSS had an extensive capital investment programme (US$ 94 million over the 5-year period 95/96 – 99/00) which included hospital renovation and upgrading projects, and donor funding only constituted around 5% of total annual expenditure.[73]

TABLE 10.2: Main donors and areas of support to the MOHSS for healthcare technology, Namibia 1992 – 1997

Donor	Support area
EU	* Provision of office equipment, clinic and hospital furniture, instruments, laboratory equipment, and solar installations
Finland	* Provision of general hospital equipment and furniture for clinics; solar installations; communication equipment in three regions * Support to development of a maintenance system based on district handymen in the north-west * Support to development of a national equipment policy
France	* Provision of general hospital equipment and furniture (Eenhana)
Luxembourg	* Provision of clinic equipment and furniture (Okavango) * Provision of mobile maintenance and repair workshops and support to establishment of a maintenance system in two regions.
Germany (GTZ)	* Provision of laboratory equipment
Germany (various NGOs)	* Provision of x-ray equipment, dental chairs, hospital beds and instruments
UNICEF	* Provision of EPI fridges, obstetric beds, medical equipment and instruments (MCH programme)
UK	* Provision of dialysis machines for WCH
India	* Provision of incubators, instruments, hospital furniture, and theatre and x-ray equipment

All three countries studied faced problems with donor support to healthcare technology, falling under the subject areas of project design, procurement, finance, technical assistance, training, and future strategies. These issues are discussed in the following sections, even though they are inter-linked and overlapping topics.

10.4 PROJECT DESIGN

There was evidence in Zambia of poorly thought out support from external agencies, and that the MOH had been vulnerable to outside pressure. For example, in 1987 kidney haemo-dialysis machines were financed for installation in regional hospitals, yet UTH was the only government hospital with the sophisticated laboratory, medical, nursing, and technical services essential for providing haemo-dialysis. Furthermore, regional dialysis would be very expensive (ie. water purification is required), and far more lives would be saved by using the funds to purchase more basic requirements (eg. infant resuscitators, theatre instruments) or provide a transport system to UTH for dialysis patients[x]. In 1990 the MOH was considering the purchase of heart-lung machines for open heart surgery. One justification was foreign currency savings since cases would not have to go abroad, but it would be difficult and costly to sustain the highly advanced support services that open-heart surgery require.

NORAD support to Botswana to develop an equipment maintenance service and construct four workshops was in line with a more *Technological Systems* approach, although it had some design constraints – there was limited equipment management development (Section 6.1.2), and no mechanism for formalizing on-the-job training initiatives (Section 7.5.2).[71] Namibia, by contrast, had a strong Planning Unit in the MOHSS which managed to ensure that most building designs, equipment specifications and contracts, etc., were appropriate. They sometimes had problems with donors who had programme strategies that conflicted with central MOHSS aims. For example, Lux Development wanted to establish a maintenance system in two regions at odds with the plans being developed centrally for a national maintenance structure.[178]

There are many examples of projects designed without a holistic technological systems viewpoint. For example the World Bank financed the construction of district hospital upgrades in Zimbabwe from the mid-80s, but would not provide support for the recurrent burden nor necessary staff accommodation.[250] As *Temple-Bird* reported a DFID project in Ghana supported equipment management in the regions but did not adequately extend it to the centre, financed equipment but not site preparation and installation sufficiently.[247] However there have been good holistically-designed projects, for example a FINNIDA laboratory equipment supply project in Pakistan. *Lehtinen, Temple-Bird, et al* stated that the project included 2-years worth of stocks of consumables and spare parts, construction of workshops, provision of tools and manuals, training of operators and maintainers, and investigation and support for possible local production initiatives.[292]

Other aspects of poor project design, are that donor programmes for healthcare technology are always directed at ministries of health, and not ministries of Works and Supplies (Section 6.2.1), nor the private sector and alternative relationships between manufacturers and the health sector (Section 9.3).

Problems occur if project design is not thought through, and is especially a danger if there are no healthcare technology management skills within donor agencies, and the recipients are in a weak negotiating position (Section 10.2). Frequently donors and recipients fail to learn from others' mistakes. When discussing science and technology and innovation in

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x. By 1990 many of these units were not installed; by 1994 many of those installed had never been used.[171]

Africa, *Davis et al* warned of design problems for technical projects, and this research shows the parallels with equipment projects in the health sector. They state that two aspects of the international development system bias choice in favour of over-designed production technologies that are procured as packages of hardware and technical managerial assistance. The first is the link between international finance and choice of technologies, whereby the lender requires products to be purchased from a particular country or region.[259]

The second is the lenders' use of foreign engineering consulting firms to design projects, manage the implantation of industrial units, and troubleshoot the start up. When this happens, key opportunities to accumulate technological capacity are not captured by nationals. When local investments in S&T are weak, the local S&T community has no basis for developing enough technical credibility to challenge the foreign consulting firms' views on local socio-technical options. Local technically-trained people simply cannot challenge these judgements on technical or economic grounds, nor are they in a position to propose credible alternatives. They warn that recourse to foreign consultants is a self-reinforcing process that does nothing to facilitate the emergence of technical capability on a national or sub-regional scale.[259]

10.5 PROCUREMENT ISSUES

Donor policies influence the pattern of procurement of healthcare technology. Sections 10.2.3 & 4 highlighted the problem of competitive international tenders and tied aid; also many donations circumvent any local selection and procurement systems.

10.5.1 Buying Appropriately

Good equipment selection requires adequate time and money to obtain sufficient information and advice; commodities health service providers and donors do not necessarily have. The equipment that developing countries choose is often influenced by the availability of finance from foreign agencies; tied-aid policies exacerbate this situation. In Zambia and Botswana, the research found many examples of poorly thought out donations, and poor selection processes. This led to inappropriate products that were too high-tech, costly to run, or of poor quality. For example, in Zambia several donated items were observed that had short operating lives; in one case only three weeks. By contrast, the Namibian MOHSS had useful planning tools such as equipment specifications, so usually managed to obtain equipment that conformed and occasionally turned back shipments of donations and second-hand goods that did not.

The ability of governments to buy appropriate equipment is affected by the procurement rules of the donors funding them. Multi- and bi-lateral funding agencies, such as the World Bank, have procurement regulations that make it difficult to adjudicate tenders on value-judgement criteria, rather than purely on the basis of the cheapest bid. The preference of donors to purchase, if not their own products, than at least products they know has led to many alternative producers going out of business even if they made products more suited to the available and different skills in developing countries (Section 9.4). This contrasts with recommendations that donors stimulate local production to create labour opportunities and promote self-sufficiency, especially for low technology items (Section 9.1).[244]

Wilson reports that although the NGO sector recognizes cheap, replicable, easily maintained, labour-intensive, suitability for purpose and resources as the criteria describing appropriate technology, they are ambivalent on the question of technology choice especially when such criteria lead to 'low-tech' solutions. This ambivalence is rooted in the perceived superiority of science-based knowledge over other forms; a belief that has a strong, ideological hold throughout the world, and means that comparatively little value is placed on prior, experiential learning.[251] A constraint which will hinder *Institutional Organization* development.

10.5.2 Buying the 'Package'

Healthcare technology needs to be purchased with a package of inputs (manuals; stocks of spare parts, consumables, and accessories; a warranty; after sales service; installation, commissioning, and training; insured freighting; payment retention terms; etc). But often this package is neglected, with many examples of equipment arriving minus one if not all of the inputs. In Zambia, the WHO-HIV programme supplied a set of items (including water purifiers) to hospital laboratories. But many laboratories soon ran out of filters for the purifiers, and the local WHO office had not succeeded in tracking down further supplies. Table 5.6 provides many examples of the procurement problems found in Botswana. Although the Namibian MOHSS usually managed to obtain equipment in line with its specifications, sometimes donors insisted on certain products and the following problems occurred:

* instruction manuals in a foreign language;
* no local agent to provide repairs;
* non-availability of spare parts;
* customs clearance, delivery, and transport not arranged;
* guarantees lapsed or not applicable;
* old, used, incomplete equipment received.

As *Temple-Bird* explains supplying healthcare technology without the necessary package of inputs is only one indication of poor procurement skills.[293] External support agencies are often short of appropriate skills in this field and make use of procurement agents (Section 10.5.3). But important issues are often not planned. This research demonstrates, for example, that training is often forgotten (Section 10.7). It is common for neither governments nor external support agencies to recognize the importance of site preparation activities, and neither party allocates sufficient resources for it. By failing to link the provision of services with the purchase of hardware, donors lose a great opportunity to standardize, thereby creating a large enough market to negotiate with the manufacturers to develop local after-sales support capacity – a major development issue.

10.5.3 Procurement Agents

Many procurement agents used by donors have good general procurement techniques (for bulk purchasing of food, paper products, general supplies, etc), but may have little knowledge of specialist items. In Botswana a French turnkey agency was involved in the referral hospital upgrade in Francistown, and *Barraclough* explained why many lessons were needed from the resulting chaos. At initial commissioning, serious deficiencies were identified and it was necessary to develop a 'shortfall list' of replacement items (see Table 5.6). However when the replacements were purchased, the same problems with procurement and supply were repeated, and the MOH found it necessary to ask an independent consultant to produce a shortfall of the shortfall list.[164]

Even by the late '90s DFID managed to fall into all known pitfalls in an equipment project to Ghana, and supplied millions of pounds worth of poor quality equipment with a very short life span. As *Temple-Bird* reported one problem was, by going for the cheapest bid, they contracted a procurement agent that had no specific experience in the purchase of medical equipment. Thus, there was confusion over interpreting specifications; not understanding the products selected; no standardization; no consolidation of shipments to facilities so different parts of the same equipment arrived many months apart; and no computerization of the facility inventories, distribution plan, or orders. With the main tender adjudication criteria being cost, cheap but not necessarily good quality items were supplied for which after sales support would be a problem.[247]

Prage studied a different field, that of research equipment in developing countries, which is relevant. He found that procurers of scientific equipment to developing countries will encounter a jungle of rules and regulations associated with the purchasing process. These govern the conditions for transport, insurance, installation, services, etc., in a terminology that is not easily accessible to a layman. They also have to be matched to the local regulations for importation, tax exemption, etc., that vary from country to country. Donors do not know, or ignore, that specific competences and a lot of time are needed to successfully coordinate and arrange for the acquisition of research equipment to developing countries. Few donors hire staff or consultants with the proper skills and experiences for these tasks.[294]

The use of procurement agents also precludes the transfer of skills to the client in specification-writing, tender-adjudication, the procurement process, freighting, insurance, customs clearance, etc. Thus, donors again lose an opportunity to develop a technical capacity within developing countries, and hinder the necessary *Institutional Organization* approach.

10.5.4 Donors Take Control of Decision-making

When there is a strong donor and contracted implementing or procurement agent, decision-making control is frequently taken away from the MOH which is left in a poor negotiating position. This research found that up to 1990, the Zambian government tended to draw up a simple 'shopping list' of equipment required, with no specification or other details included, and then let the donor take control. This can lead to a failure to consult with local staff. In the Ghanaian example in Section 10.2.2, heads of the regional hospitals being upgraded told me that they would have downplayed the sort of technology supplied, if consulted, since they did not have the skills and finances to keep it going. Not only was their equipment sourced from a variety of countries, each hospital had different makes, none used by neighbouring countries. Thus a large enough market had not been made to encourage manufacturers to set up after-sales support centres.[278]

By taking control, implementing and procurement agents often do not conform to MOH requirements.[278] In Botswana, the French turnkey agency did not consult with the MOW which was to maintain the plumbing installations, with disastrous results (Section 5.1.2). However, by the time the Botswanans upgraded the central referral hospital in the capital, some lessons had been learnt and they introduced their own project co-ordination team. This research resulted in such an initiative under the DFID management strengthening project at three referral hospitals in Zambia.[171] This initiative involves:-

* A project (and procurement) committee made up of local technical, medical, financial managers, etc who have an input and veto into the design, specifications, procurement package, and purchase sources.
* An implementing/procurement agent, contracted to act only as advisor to MOH, to do things on their behalf rather than acting in their place, and seen as a resource which helps with all the administration and paperwork.

* A tender process that preferably involves selective bidding (to ensure that an element of standardization can be maintained, and preferred sourcing is adhered to), that can be undertaken by either the agent or the MOH.
* The agent displaying the bids in comparison tables so that the MOH can choose the most economically advantageous option (taking into account a full range of issues and not just the cheapest price).

Such strategies are required to enable developing countries to regain some control. Where there is a strong local procurement unit it is possible to subject gifts to the same scrutiny as is the purchase of equipment. In Mozambique, for example, the maintenance centre is asked to advise on its capacity to assure maintenance before a donation is accepted.[202] Unfortunately guidelines for equipment donations are complex and have been slow to appear; however various agencies have now drafted some.[295,296]

10.6 TECHNICAL ASSISTANCE

Technical assistance comes in the form of short-term consultants, long-term placements, and implementing agencies. In Zambia (1990), UTH had received a technician from JICA and short-term technical consultancy support from USAID, and DFID provided consultancy support nationally for the review of the equipment sector (*Haddon & Temple-Bird*).[69] From 1995, DFID funded a project providing engineering consultancy support to assist with equipment management at three central hospitals (*Temple-Bird et al*)[184,280], a VSO plant engineer, consultancy support for equipment management to Lusaka urban district health authority (*Temple-Bird*)[297], as well as a procurement agent.[171]

In Botswana (1992), CIM hired an engineer to coordinate maintenance and training for mission hospital equipment (Section 6.1.2). NORAD's technical assistance for healthcare technology was: a senior engineer at the central hospital workshop, Assistant Director for Technical Support Services, a technical officer at Maun district hospital, and (in 1994) the Chief Engineer for the MOH. Unfortunately, most of these contracts were short term (3-year), and MOH training plans did not enable locals with specialist skills to be developed before the expatriates left. Later on, consultancy support was used for district and primary hospital upgrading programmes (*Temple-Bird & Visser*).[298,299] In Namibia (1997), assorted agencies provided volunteer engineers for rural hospital equipment maintenance programmes, and FINNIDA and the EU provided health management advisors at ministerial and regional level. By 2000, FINNIDA had provided consultancy support for equipment management (*Temple-Bird*)[178], a Chief Engineer for the ministry, as well as short term advisors for various plant and equipment issues.[175]

Technical assistance in this field is crucial, as long as mechanisms are put in place for skills to be transferred and means are provided for individuals to achieve project outcomes. Although an important development intervention, it is rarely pursued by donors for a number of reasons: they have few large projects supporting equipment management development, are short of in-house healthcare technology skills, and cannot find suitable engineers who want to uproot their families and live abroad.

Another aspect of technical assistance is the use of suitable technical implementing agencies. In Nicaragua, FINNIDA contracted the Pan-American Health Organization (PAHO) to be its implementing agent, only to find that this strong organization was too influential in project execution, and took control away from the Ministry of Health (MINSA). *Temple-Bird et al* found that they contracted project staff in such a way that they felt allegiance to and reported only to PAHO, instead of MINSA, and tried to channel project activities in a direction that would advance PAHO's own strategies for the sub-region.[275]

Development literature stresses that one of the most important elements of aid cooperation is building institutional and individual capacities. It is plausible that capacity building can significantly contribute to the sustainability of aid, and is therefore an indispensable tool (Chapter 7). But *Halbwachs* states that its contribution can hardly be measured in terms of cost-effectiveness.[262] In the NGO sector *Wilson* reports that one important issue, raised by his interviews with UK NGO workers involved in small-scale development projects, concerns what they did **not** say. Although they articulated views on technology, they never explicitly addressed the question of technological capability and hence its importance in underpinning economic development went unrecognized. Thus, he feels that the existence of technological capability building in projects supported by these NGOs tended to be a matter of chance rather than design.[251] As Section 7.7 stressed, building human capacity should be at least one of the key outcomes of development activities, and be pursued for healthcare technology.

10.7 TRAINING ISSUES

Since donors regularly omitted training from the package of inputs when purchasing equipment, many operators and maintainers in the three case study countries had never been trained by the equipment supplier either at their health facility or at the factory site (Section 7.5.5). In Zambia, all the medical equipment maintenance technicians were awaiting initial or further training opportunities abroad (Section 7.5.4). The MOH tried to send staff in turn to the few available international courses that would accept their (low) entry qualifications, and had obtained a number of WHO scholarships for courses at WHO-run training centres. In Botswana, technical staff had been sent to longer courses of a higher level in the UK and Canada, funded by scholarships from NORAD, the British Council, and

WHO. Namibia had few technical staff and had not used donor scholarships for training abroad (although FINNIDA supported on-the-job training of handymen and workhands[300]).

Some donors have increased the local and regional training locations for healthcare technology. As Section 7.5.4 shows, GTZ assisted the development of several training courses in Kenya, Jordan, Senegal, and El Salvador. WHO used to run several courses in Africa (now closed), the Commonwealth Secretariat and USAID supported a training course in Swaziland (only open on and off), FINNIDA strengthened basic training for operators in Zambia, and DFID developed a course for hospital administrators in Zimbabwe (now closed). *Müller* in 1994 called for a concerted effort to develop regional training centres in Sub-Saharan Africa.[254] Even if training locations exist, staff still need access to scholarships in order to attend.

People in developing countries, who wished to train for a career or skill, used to be able to approach external support agencies for assistance with scholarships. Some agencies, such as the British Council, regularly offered access to a wide range of courses. However, by the mid-90s donor policy changed so that training was linked to the presence of a donor equipment project, healthcare technology projects were reduced, many countries had none, many donors supported none, and therefore offered no training scholarships.[202] The DFID-Zambia hospital project, although including a substantial sum for new equipment and equipment rehabilitation and management development over five years, was designed without any training scholarships at all.[171]

10.8 FINANCIAL ISSUES

As Chapter 8 concluded, capital expenditure on equipment often only falls under development votes financed by large donor projects. The remaining capital requirements and the vast replacement backlog are omitted.

Halbwachs believes that one of the most critical aspects of supplying equipment is the 'after costs'. He asks "how often is an attempt made to justify donations by arguing that some people will have a nice piece of medical apparatus for free? Most donors do not know that operating costs alone can range from 5 – 100 % per year of the procurement costs".[244] As Section 8.4.1 shows, it is a major management failing by both ministries and donors to forget recurrent expenditure for healthcare technology, and to disregard the link between planned capital expenditure and the resources required to keep new items functioning. This short-term perspective is a major development issue.

Halbwachs reports that in 26 developing economies in Asia and Africa, more than 25% of health expenditure was contributed by donors, whilst in eight countries external aid exceeded 50%. He thus calls upon the donor community to show more commitment to promoting rational physical asset management (PAM) for those countries, in two ways: i) assisting countries in the development of adequate PAM systems, and ii) contributing to recurrent expenditures for maintenance.[243] He recognizes that contributing to recurrent budgets is a controversial issue. The ethical considerations and presumed interest of donor organizations in sustaining the function of their contributions, would favour such an idea. However, a more cynical viewpoint is that some donors have more interest in promoting their home industry by maximising, for example, the output of medical equipment to developing economies. In addition, one may fear that budget aid may kill national initiatives for developing self-contained financing systems. However, he believes that the 'pro' arguments are more convincing in view of the serious situation of the majority of patients. He proposes an initiative (and pre-condition), whereby contributions to maintenance are distributed via a national body and through the regular budgetary channels to avoid parallel structures. An acceptable body could be created as a foundation with suitable legal status, and controlled by the donors involved and the national stakeholders in public health services. He believes such a foundation could in the long term evolve into a professional society and/or a spare part procurement agency.[243]

10.9 STRATEGIES FOR THE FUTURE

Current donor trends support structural adjustment, health sector reform, restructuring, decentralization, and essential health packages, but a by-product of many of these strategies is an increase in equipment stock that countries cannot afford (Section 8.5). A recent study of decentralization in the health sector, talks of the myths that have arisen and recognizes that many of these new initiatives are not working.[301] This Thesis has identified several examples, such as decentralization before suitable work methods are developed (Section 6.2.2.), premature decentralization of control of funds in Namibia (Section 6.1.3), privatization of mines in Zambia and the discontinuation of their health and training role (Section 6.1.1), decentralization of equipment leading to duplication of stock and resources and high operation costs (Section 8.4.1 & 10.4), and failure of essential PPM systems as their control is decentralized (Section 8.4.2). In addition, structural adjustment is not necessarily helping. For example, the failure by Zambia to meet terms due to the harsh social consequences led to donor withdrawal (Section 10.3), cost recovery in Zimbabwe was found to be over-hyped and could never cover maintenance costs (Section 8.5), the emphasis on primary product export drives rather than development of technical capacity in industry (Section 9.4).

Although SIP and SWAP initiatives (Section 10.1) sound logical and sensible, *Halbwachs* states that daily reality constantly poses challenges in balancing the jungle of counteracting interests. He warns that more frequently governments and aid organizations see the future of healthcare in the private sector, as if the free market out of its own creative power would be able to establish adequate care for both rich and poor in low-income countries. This does not even work satisfactorily in wealthy countries.[262] A recent study into the key challenges facing healthcare technology in developing countries, made use of this research to argue that the three current trends of: health sector reform, development of district health management systems, and SWAP funding are introducing major changes into the health sector. But it warned that there is a limited financial envelope for health and in **none** of these initiatives are healthcare technology issues specifically addressed (*Temple-Bird).*[302]

Chapter 7 concluded that in order to develop national technical management capacities, external support agencies should take *institutional organization* initiatives and pursue, as a part of health sector reform, the involvement of: i) general health staff in the first level of the maintenance service, and ii) equipment management in district health management systems. In this way, health planners can direct more attention to improving the performance of health service delivery, and consequently improve management of the assets of health facilities.[248]

Funds for aid are dwindling, and some donors are reducing support for health in general, and healthcare technology specifically. Even GTZ, who is recognized as the most active and valued agency in this field (participating in national maintenance service projects in nine developing countries and health projects with maintenance components in a further 12), is now reducing its support.[302]

In order to provide proof for donors that may justify their continued support for this sector, Section 8.5 asked whether cost-benefit analysis of maintenance would help in order to secure funding for it. *Halbwachs* believes that if the aim is to improve health service performance, then performance must be made measurable in future. A core part of a quality management approach would be to broaden the evidence base of healthcare technology management. This would provide a tool and leverage for optimising processes related to equipment management and to all other management areas in health facilities; the sort of evidence required is:

* operational criteria (eg. downtime of selected items)
* criteria relating to quality of care (eg. number of additional patient visits due to equipment failures)
* economic criteria (eg. cost-benefit relation).[303]

Section 9.3 concluded that much work is still required by donors, public and private sectors to provide securer markets for products and industrial development. For technological capacity building in general, *Wilson* believes that the sort of projects that contribute to fundamental development are those that provide extensive opportunities for acquiring tangible and relevant new skills. Projects should specifically provide productive and challenging job opportunities, for it is through these that people acquire skills that prepare them for innovations in future. He reports that the OECD believes aid agencies should in future shift their focus from individual project support to strategic capacity building, and include:

* sensitization and education;
* national and international science and technology institution-building;
* support for private sector science and technology development;
* adaptation of aid processes to serve the additional purpose of national science and technology capacity-building.[251]

10.10 CONCLUSION

There are a large number of different types of donors, many of which supply equipment to health service providers in developing countries, although fewer are involved in projects that develop the healthcare technology sector. There is little reference to this sector in donor literature. It could be argued that the form in which donor support is provided is unimportant where the recipient country is clear on the direction in which it wishes to go, and has the administrative capacity to take it there. In other words, an organized equipment system would act as a control system. For example, with a national equipment development policy and firm multi-year equipment purchasing plan (Section 8.4.1), it would be possible to define projects through which donors could support elements of the programme. In a situation of scarce administrative resources, however, it is unrealistic to assume that donor policies do not influence the pattern of development.[304-6]

The analysis shows that the short-comings arising from donor actions reflect many major development issues already highlighted in Chapters 7 – 9, such as:

* the need to build indigenous technological capacities;
* short-termism compromising the sustainability of investment;
* public/private collaboration to finance all parts of the cost iceberg;
* new modes of co-operation with private sector companies, to provide the environment for commitment to after-sales support;
* the need for regional strategies.

The analysis also introduces further major development issues:

* fashions in development thinking can randomly marginalize sectors, eg. engineering is not seen as important within the health sector, and funds are being withdrawn;
* the need to hand over more control to recipients and empower stakeholders.

Trends and fashions in aid mean that donor support for equipment has often been short-term, piecemeal, and unsustainable, in addition the healthcare technology sector has been affected by the way in which donors function. For example, the slowness of implementation means that prevailing situations deteriorate; by the time many donors had introduced maintenance strategies into their projects, the equipment had aged to a point beyond rehabilitation and simply needed replacement. Negotiating with the ministry responsible for external aid, can mean that the input from the health client is questionable. International competitive tender rules have proved unsuitable for buying complex equipment, and tied aid does nothing to help rationalize the sector and support local standardization initiatives. Lack of technical skills for this field within donor agencies, means weak organizational structure, technical capacity, knowledge retention and gatekeepers needed to work as Learning Organizations. All these aspects of aid form a part of the *Development* perspective studied in this Chapter.

In the three countries studied, support for healthcare technology was rarely addressed as a national development issue. Zambia was very poor and reliant on outside help for its equipment sector, but was also subject to significant pressure regarding the form that support would take. Botswana had substantial facility upgrading plans, and received significant support that proved to have both positive and negative effects; of the three countries, they received the most development support towards a national healthcare technology maintenance system. On the other hand, Namibia's MOHSS had a strong Planning Unit which had developed tools (equipment specifications and contracts) which they encouraged donors to conform to. Out of their large development programme, the most substantial input for buying equipment was by the MOHSS itself. Even so, all three countries faced problems with donor support in the areas of project design, procurement, technical assistance, training, finance, and future strategies.

Important issues were identified that donors need to address. Project design is especially a problem if there are no in-house skills in donor organizations and if too much emphasis is put on developed nations' idea of norms. Most countries face bulk healthcare technology replacement requirements, but there is no evidence of donor interest in funding this. The style of project implementation often leads to donors and their agents taking control away from the recipients. Long-term technical assistance to this field is little used, and represents a lost opportunity for developing national technical management capacities. The reduction in scholarships also means that skill development opportunities have been limited, especially as maintenance training often does not appear in MOH training plans. Both donors and health service providers fail to plan for recurrent support for the equipment procured, even though experts recommend that 30% of donor support should be for the on-going management of equipment supplied.[307,308] As it appears that health sector reform strategies are not taking account of healthcare technology management strategies, and aid is dwindling, the future for this sector looks bleak unless changes in support are made.

In answer to my question "*can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?*", the analysis shows that a number of initiatives provide improved results. In addition, the evidence shows that this research has provided insights for my subsequent work and vice versa. The positive examples are:

* projects designed holistically, especially those with a management component;
* strong national equipment units with 'tools', such as national equipment plans, specifications and contracts, policies on turning back unsuitable donations;
* a long-term perspective and assistance to national equipment services;
* recipients taking the lead role in equipment projects, with project teams that use the donor and their implementing/procurement agent only as a resource tool;
* good use of technical assistance (long-term placements and short consultancies) together with mechanisms for passing on skills;
* provision of training scholarships and development of local/regional training courses;
* establishment of donor-primed revolving funds for the supply of spare parts and recurrent supplies;
* guidelines for donors when supplying equipment;
* moves to locate healthcare technology within donors' standard operational divisions.

There are other potential areas of positive donor influence. They have large amounts of data (grey material) on lessons learnt regarding healthcare technology projects; if this was accessible perhaps countries would not continually make the same mistakes. A different approach to equipment supply (standardization, ensuring after sales support provision, etc) would create more stable markets, and mean manufacturers develop a long-term presence in developing countries. Also, support of local production of equipment through economy-wide policies would facilitate indigenous technical change in industry.

Experts have called for several initiatives that have potential for the future, if pursued. *Remmelzwaal* believes that equipment has its own specific characteristics of distant manufacturers, fast changing technology, maintenance intensity, etc. Thus, its management calls for specific capabilities and competences, which usually are not addressed in health sector education programmes or existing donor projects to develop managerial skills of health staff. He feels that historical evidence suggests that these skills do not develop from experience, from 'learning by doing', as would be expected. For these reasons, donors need to finance the development of certain technical and managerial skills, on the part of the indigenous managers, as an integral and vital component of any equipment aid package.[308]

Johnson & Wilson believe that sustainability and sustainable development are socially constructed concepts which require negotiation between stakeholders to set parameters for action. Negotiation is likely to involve power relations and conflict, as well as engaging with uncertain and even turbulent social contexts. It is an ongoing process involving participation of key stakeholders in which they can a) monitor, review, and evaluate processes, outputs and outcomes (performance assessment), and b) engage in a dynamic process of learning and innovation, in ideas, technologies and organizational practices (capacity building). They believe such a task requires i) participative management and implementation, and ii) the ability to investigate and evaluate.[229]

The OECD argues that there is a strong tendency for aid to supply capital equipment on a highly subsidized basis, while at the same time failing to ensure that the human resource capacity and recurrent expenditure requirements are available. This propensity has a negative impact on the capacity to manage technical change (*Wilson*).[251] This capacity for managing technical change is the focus of my entire Thesis, thus external support agencies have an important role to play. Therefore as part of the conclusions in Chapter 11, I will look at how donors, together with other players, are in a position to help overcome all five key constraints identified in the healthcare technology sector in developing countries (see Section 5.3).

CHAPTER ELEVEN: OVERALL SUMMARY AND CONCLUSIONS

This Thesis describes my experience gained from working for 20 years as an engineer and a management consultant in the healthcare technology field in developing countries, together with specific data drawn from three country case studies in Sub-Saharan Africa at certain times over the last decade (1990, 1992, and 1997), and a review of supporting literature. The country fieldwork involved the examination of thousands of pieces of equipment, the detailed study of systems of work and organization in a variety of public and private sector institutions, and the analysis of large quantities of information and statistics. This Thesis has also been informed by my continued work in the three countries in subsequent years.

Much of the data gathered and presented as well as the analytical outcome is original. Undertaking the PhD research at the same time as continuing to work in this field provided insights that have allowed cross-fertilization between my research and work and enhanced both.

11.1 IMPORTANCE OF THE SUBJECT

Chapter 2 sets the scene, and shows that health service providers in SSA must manage a vast range of equipment falling under the umbrella term of healthcare technology. At the same time they spend little per capita on equipment. It is necessary to make the most of existing resources. However, they face problems at all levels with: the age of equipment and its need for replacement; poor selection of equipment with limited choices of appropriate technology; non-functioning equipment due to poor maintenance resources, weak industrial sectors, and poor manufacturers' support; instances of negative influence of external support agencies, with only piecemeal attempts to improve the situation; and numerous actors working in a little known field.

Health service providers try to import foreign technology into their working environments. Thus the management of healthcare technology in developing countries is a crucial subject, if effective healthcare delivery is to continue. My years of experience in this field seeded my interest in the sustainability of the sector, which led to my first research question:-

"How can the sustainability of the healthcare technology sector be improved in Sub-Saharan Africa?"

11.2 STARTING POINT – AN ANALYTICAL TOOL

During earlier research in 1988, I felt many problems arose because technology was not being managed as a complex whole. At that time, the idea of creating healthcare technology management units in ministries of health in developing countries was relatively new. The modelling framework I developed as a tool for studying this sector was original and is the starting point of this Thesis.[3]

Chapter 4 describes this modelling framework in full. It provides an holistic framework for studying the healthcare technology sector in a country, based on the Healthcare Technology Package as a system. As seen in Section 2.3.11, decisions that affect the life of equipment are made on a daily basis by a wide range of different staff. It is necessary to disentangle their activities, roles, and responsibilities in order to get a feeling for the whole task. The framework developed evolved over the period of case study fieldwork, as a result of the learning process involved in its application (Section 11.3). In its final form the approach taken was (1) to break the package of necessary inputs into its component sub-systems that cover the whole range of activities involved throughout an equipment's life. Then, (2) identify the sub-system actors that could provide the various elements of the package, and (3) identify the background context sub-systems in which the equipment is trying to function nationally.

The modelling framework is structured to enable information to be gathered in a number of areas, in this way it is possible to analyze the 19 sub-systems of a *Technological System*. The HTP is split into its eleven component sub-systems for analytical purposes, so that the activities which occur in the equipment's life-cycle are considered first: i) management and planning, ii) allocation of financial resources, iii) selection of technology, iv) procurement, v) preparation for technology use, vi) continued operation, vii) maintenance and repair. Then, other elements are considered which are informed by the analysis of the first seven, namely: viii) personnel, ix) training, x) technology assessment, research, and product development, and xi) local production.

Information is also gathered on the four categories of *Institution* involved in delivering the HTP system. The four sub-system actors with a role to play are: a) health service providers, b) public sector maintenance organizations, c) private sector institutions (both national and international), and d) the national support environment (comprising national and international actors). In addition, it is necessary to gather specific relevant background statistics that mark the stage of national *Development*. The four context sub-systems cover: health, economics, education, and industrial parameters within a country.

Traditional technology transfer literature stresses the need to look at the package of inputs in a transfer. Thus my unpackaging approach did not set a precedent, but used a process applied in technology transfer in general. At the beginning of my PhD research, I studied the technology transfer literature hoping that it would show the success of unpackaging and its efficacy in other fields. One important finding of Section 4.4 was that the literature proved weak from an engineering point of view. Some of the literature did stress the need for organizational capabilities, and the role of suppliers and the national support environment, which I was able to pursue during my research. But I needed to know if the equipment could be maintained, how much staff training was required, could supplies of consumable materials and spares be found and afforded, how long the equipment lasted once the transferor left, etc. This was not covered.

My experience led me to approach the subject from three perspectives, which form my Thesis framework to consider healthcare technology as:-

* a *Technological System*
* an *Institutional Organization* issue, and
* a *Development* issue.

11.3 USE OF THE HEURISTIC TOOL – A *TECHNOLOGICAL SYSTEMS* APPROACH

The PhD research studied healthcare technology in three case study countries over a period of time – Zambia in 1990, Botswana in 1992, and Namibia in 1997. One major result was the examination, counting, and systematic evaluation of thousands of pieces of equipment. This formed my original raw data, which it was necessary to interpret in order to discover why, for example, the equipment was not working or inappropriate models were purchased. Thus, one aim of the PhD research was to apply the tool in these three countries in order to gather the extra data needed to answer such questions, and for modelling purposes.

Chapter 3 describes the various methodologies used, including the country case studies. The modelling framework was first applied as a pilot in Zambia, a more structured application method was developed for Botswana, and 'How To' guidelines were produced for Namibia that the country staff applied with my assistance. Thus, the Thesis reports on the learning process involved in studying three countries at three different times over a decade. Section 3.3 discusses how the learning process enabled the first framework to be refined over years to its final form and method of application. Chapter 4 describes the systems analysis used to develop the final modelling framework, as an outcome of the learning process.

Chapter 5 shows that the different countries chosen offered a varied experience. They were all facing similar problems with healthcare technology: they had old equipment with limited maintenance support available, so that as much as 35 – 70% of their stock was out of order. However Botswana and Namibia had not yet fallen to the dire straits found in Zambia. None had strong equipment management structures within the ministries of health. All were grappling with how to resolve the problem of the maintenance of plant, service supplies, and buildings by other ministries (such as Works). All the countries had tiny private industrial sectors to support healthcare technology.

In Zambia, the mine facilities were faring better than government ones mainly due to the mines' technology management philosophy. Equipment in government facilities in Botswana were in a better condition to those in Zambia, mainly due to a concentrated input of NORAD support to build maintenance services over time. Botswanan mission facilities were better off than government ones due to simpler technology and sometimes more resources, and mine facilities fared better still due to more money and the use of support from South Africa. In Namibian facilities there were very little government maintenance capabilities, but the country had the greatest potential for private sector support due to close business links with South Africa. However, the MOHSS and MOW had no information readily available on the real state of its equipment.

The modelling framework involved a *Technological Systems* approach. The approach generated a great deal of data for all 19 sub-systems. As summarized in Chapter 5, the equipment and its management was found to be in a very poor state. This was partly due to age, partly due to poor management systems made worse by the complex range of uncoordinated bodies involved, with lack of money, technical skills, and support exacerbating the situation.

The application of the modelling framework proved very effective. Chapters 5 – 10 recount valuable data with concrete illustrations of the common problems expected, as well as many unexpected problems. Much data was previously unknown, and the identification and presentation of it was original. Analysis of the sub-systems allowed dissection of the sector to find out what was happening, by whom, and could identify good practice and major constraints. In addition, the structure of the tool used in the systems approach provided a framework for presenting the results that was clear and useful.

The identification of such information was beneficial. Most important was the impetus it gave to developing national equipment policies, the starting point for taking a management approach to healthcare technology. The MOH in Botswana went on to use the information to instigate initiatives and plans for change. In Namibia, the MOHSS went on to formulate healthcare technology policy. In addition, the study prompted the ministries to introduce a variety of new initiatives, including a range of management tools discussed in this Thesis. The learning process involved in this research continues. The book 'Practical Steps for Developing Health Care Technology Policy' developed from the experience, is a comprehensive and useful step-by-step manual for policy-makers and health service managers in developing countries, based around the HTP system modelling framework.[75]

11.4 OVERARCHING THEMES – KEY CONSTRAINTS

Chapter 5 showed that each country needed national equipment management systems, and skills and resources to implement them. It also showed the important role of the private sector and donors – they were two key players. From the data gathered, and the conditions found in each country, several reoccurring overarching themes appeared. Thus this research has led to answers to my second research question:-

"What are the key constraints to sustainability and what common problems persist?"

Five key constraints emerged:

a. the institutional framework available for delivering healthcare technology management throughout the country;
b. the strategies taken to train personnel and develop a national technical management capacity;
c. sufficient allocation of financial resources;
d. the technical support available from the private sector;
e. the role played by external support agencies.

The nature of these issues introduced two further perspectives, to add to the technological systems perspective – an *Institutional Organization* approach, and a *Development* approach (Sections 11.5 and 11.6). The remainder of my research focused on these, and Chapters 6 – 10 of this Thesis present and explore the five themes (listed above).

11.5 AN *INSTITUTIONAL ORGANIZATION* APPROACH

In Chapter 6, I investigate the institutional framework available for delivering healthcare technology management, and in Chapter 7 the strategies taken to train personnel and develop a national technical management capacity. Both these topics enabled me to pursue my second perspective – the *Institutional Organization* approach.

11.5.1 Institutional Framework for Delivering Technology Management

In Chapter 6, I study equipment management by health service providers (public, independent, private) and by parts of the national support environment (mainly other ministries involved in purchase and maintenance). In all three countries, equipment had deteriorated partly due to lack of management, but also to a too-complex management system. There was no defined equipment management structure and too many people involved in aspects of management who operated in an uncoordinated fashion. There was a severe shortage of technical staff trying to manage an unknown given the limited data concerning the equipment stock. Zambia had no management delivery structure or management tools for equipment. Although Namibia had developed some tools it had no delivery structure for them. Botswana had made the most progress in developing a network of maintenance workshops across the country, but had the most complicated management delivery system that constrained management activities. The identification and presentation of the complexity involved was an original part of the research.

Each country needed to develop national 'Healthcare Technical Services' in the health service provider organizations as promulgated by the WHO (Section 6.2.1), but the analysis shows that they are also required in the public sector maintenance organizations. Botswana and Namibia both faced problems managing the role of the Ministry of Works that was responsible for maintaining all government property. Botswana faced the worst situation with six maintenance organizations involved in the public health sector. Zambia had introduced an initiative that could be a good model for other countries by disbanding the MOW teams and absorbing the staff to develop multi-disciplinary maintenance teams. These cadres worked together under one organization for the good of the health facility as whole.

Private health facilities were better able to manage as they had access to greater resources. Missions were struggling with equipment management. But the mine hospitals fared the best as they transferred the equipment management philosophy from their mining activities into their health facilities. However in none of the countries was there any coordination on equipment issues between these differing health service providers. All were struggling with the same issues in isolation.

By investigating how the health service providers were managing complexity and the limited policies and procedures developed, I answered my third research question:-

"What are the institutional organization constraints to building sustainability for healthcare technology?"

Chapter 6 shows that my research identified three major constraints:

* the absence of an equipment management delivery structure;
* the shortage of technical management capacity;
* institutional memory loss.

Analysis of relevant literature showed that health service providers do not have the organizational design suited to support learning in the field of healthcare technology. To be a Learning Organization requires absorptive capacity, which is a measure of the ability of an organization to assimilate and exploit new information. Absorptive capacity depends on the structure of communication between the external environment and the organization, as well as among the sub-units of the organization, and also on the character and distribution of expertise within the organization. It is not resident in any single individual, but depends on the links across a mosaic of individual capabilities. Thus, it requires a critical mass of technical voices within decision-making bodies.

Technical management capacity depends on the whole group having some level of relevant background knowledge. Thus there is a need for i) in-house technical staff with skills in healthcare technology management, who ii) will be the focal point for communication on technical matters with equipment suppliers, technical support organizations, and other health service managers, but iii) there is also a need to spread technical knowledge wider within organizations, both to ensure a general understanding of the issues, but also to develop healthcare technology managers from other professions since there is a shortage of technical staff. With a high turnover of staff it is proving difficult to retain institutional memories for correctly handling technological issues. One dangerous assumption was the presumption that increases in individual learning automatically led to increases in organizational learning.

The analysis shows that these issues do not apply exclusively to the health service providers, but also to public sector maintenance organizations (Chapter 6), local private industry (Chapter 9), and external support agencies (Chapter 10). All these institutions risk being locked-out of further technological understanding due to their low investment in absorptive capacity for the healthcare technology field. Heavy reliance on temporary external consultants allows hard-won knowledge to be lost to an organization without mechanisms to ensure continued improvement. The best organizational design to support learning is team work.

It is important, therefore, for countries and donors to look carefully at the restructuring, decentralization, and reform activities currently taking place in the health sector, and to ensure that their goal is to develop Learning Organizations in the field of healthcare technology, and to consider how this goal can be extended to key players in other ministries and industry.

The study and analysis in the Thesis enables me to provide a series of answers to my fourth research question:-

"Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?"

These answers are drawn from different chapters and arise from different areas of investigation. Over the next few pages, the answers are presented in boxes that summarize major conclusions from the Thesis.

Box 11.1 summarizes some answers to my fourth research question, regarding the institutional framework for delivering technology management.

BOX 11.1:	**Alternative strategies in developing countries for management delivery (see Section 6.3)**

Current initiatives which work

* rationalize the role of the ministries of health and works, and develop in-house maintenance teams in the health sector comprising technical staff with skills from all different maintenance disciplines working under one organization;
* expand healthcare technology expertise by developing the first-level of in-house maintenance teams to include general health staff;
* develop management tools for healthcare technology.

Initiatives with potential if implemented

* develop a national Healthcare Technical Service to deliver single technical management from the ministry to clinic level through a network of physical management and maintenance workshops, using outreach services and standardized procedures;
* include technical representation and viewpoint into management bodies in health service providers and donors;
* pursue strategies and procedures to ensure health service providers, other maintenance ministries, local private industry, and donors become Learning Organizations for healthcare technology, and combat institutional memory loss.

11.5.2 Technical Management Capacity

The acute shortage of technical management skills is explored in Chapter 7. Their availability is a crucial component of the absorptive capacities of organizations. Section 7.2 shows that all three countries were short of equipment user skills. One reason was the lack of equipment-related modules in basic training courses for health staff. However, not all user skills were poor. Different skills from those in developed nations accommodated the different types of technology in use.

All health service providers were short of maintainers. The ways for staff to gain qualifications was complex, and the presentation of the routes available was original. Five strategies were identified for increasing technical skills:

* ensure the skill development requirements for maintainers are incorporated into HRD plans;
* use a variety of options to hire staff at different skill levels and develop technical skills in-service;
* build on the region's recognized structure of trade, vocational, industrial, and academic training, make the best use of existing courses (nationally and internationally), and negotiate for the expansion of provision and modification of local courses to be more appropriate for healthcare technology maintenance;
* make better use of the training resources provided by manufacturers;
* flag healthcare technology training as a specific and important component for the country programmes of external support agencies, and obtain scholarships for some of the needs.

Chapter 7 recognizes that simply training is not enough, and investigates other motivational issues for developing a national technical management capacity. It shows that the new personnel management techniques have been slow to arrive in the three countries studied.

It will take a long time to obtain a large pool of technical staff in developing countries, but national technical management capacity can be increased by involving more general staff. Ghana, Madagascar, and Namibia have included general staff into the first level of their national Healthcare Technical Service, and have started introducing equipment management into district health management systems. Chapter 9 shows that strategies to strengthen equipment services could also develop local technical capabilities in the private sector. The building of human capacity must be a key outcome of development activities if sustainable development is to be achieved. Thus by studying personnel issues, I began the third perspective for my Thesis – a *Development* approach.

In answer to my fourth research question, Box 11.2 summarizes different experiences regarding technical management capacity.

BOX 11.2:	**Alternative strategies in developing countries for developing technical capacity (see Section 7.7)**

Current initiatives which work

* organize in-house training of users to increase the equipment skills of operator staff;
* develop practical maintenance training guides for equipment users;
* develop illustrated reference materials to aid purchase and supplies staff to identify items;
* include training in equipment purchase/tender documents;
* develop an hospital administrator cadre;
* develop an establishment structure for the national equipment management service, from the ministry down to a first-level made up of general health staff at facility level;
* develop a national medical equipment maintenance training capacity, that may also be a regional resource;
* introduce personnel management strategies.

Initiatives with potential if implemented

* introduce equipment-related modules in the basic training curricula for clinical, paramedical, and support staff;
* liaise with Trade Testing authorities to develop a new apprenticeable trade for medical equipment maintenance artisans, so they can attain qualifications;
* liaise with polytechnics and the Ministry of Education to combine a mix of existing diploma modules to produce entry-level general maintenance technicians, and possibly additional medical equipment options;
* liaise with industry (such as mines) to make use of their training capabilities.

11.6 A *DEVELOPMENT* APPROACH

The *Development* approach continues with a study of financial resource allocation (Chapter 8), technical support availability from the private sector (Chapter 9), and the role of external support agencies (Chapter 10). From the analysis, a variety of major development issues emerged.

11.6.1 Allocation of Financial Resources

Healthcare technology management contributes to the economy of healthcare delivery and quality. It is a core activity, and needs to receive core finance. However, resource constraints are a feature of developing countries.

Cost information is a vital managerial tool, but Chapter 8 shows it was not available in the three countries studied. There were limited equipment expenditure records, budgets were not set up suitably, and in the absence of equipment inventories stock values were only estimated. The PhD research made original calculations that prompted the MOHs to do likewise (Section 11.3).

Most development funding is earmarked for capital expenditure for new or upgraded facilities and is often donor-supported. International recommendations state that 10% of equipment stock values are required annually for replacing equipment, but the governments spent on average 1% or less. Also 6% of equipment stock values are required annually for equipment maintenance and repair, but governments spent on average 1% or less. The irony is that it has taken so long to raise interest amongst countries and donors to increase support for maintenance, that in the meantime the equipment has become so old that it simply needs replacing and can no longer be rehabilitated.

These constraints led to crisis management in the three countries, with limited financial planning for equipment, and no link between development expenditure (expansion) and the recurrent allocations required to keep the equipment functioning.

A great deal of recent health sector reform has concentrated on restructuring of health services, decentralization, more primary healthcare, and essential health packages. However countries cannot afford what they currently own, let alone afford the increase in equipment stock that this represents. The increase in the proportion of resources going towards primary healthcare cannot be at the expense of the well-being of hospital equipment since it is an important part of the referral system. Also the increase in the staff salary bill cannot be at the expense of the functioning equipment that they need to do their jobs.

The gathering of financial, technical, and clinical data relating to equipment, then undertaking cost-benefit analysis may provide sufficient proof for government and donors of the need to finance equipment management activities. From the literature, it is apparent that experts are asking donors to help with recurrent expenditure for equipment, as well as the development of equipment management systems and the strengthening of regional maintenance capabilities (Chapter 10).

Box 11.3 summarizes further answers to my fourth research question, regarding the allocation of finances.

BOX 11.3:	**Alternative strategies in developing countries for allocating finances (see Section 8.5)**

Current initiatives which work

* rethink budget layouts and accounting methods to reflect equipment expenditures;
* start equipment inventories and stock value calculations;
* allocate a mandatory 10% of budgets for health facilities and authorities (net salaries) to be set aside for maintenance;
* sell government property not in use and residential property not in remote locations, to finance the maintenance of government buildings;
* recognize the need to retain central control of the organization and finance of some key equipment activities, such as PPM.

Initiatives with potential if implemented

* break down MOW's budget by client ministry and preferably by facility, thereby enable each ministry to request a maintenance budget which reflects the number and size of their facilities;
* ensure all equipment procured (by the health service provider and external support agencies) includes the required package of inputs;
* undertake usage rate exercises for equipment consumables and spare parts so that recurrent budgets can be planned on real needs;
* develop a Core Equipment Expenditure Plan for the long-term, which is integrated into the MOF plan for the health service;
* place as much emphasis on supporting healthcare technology management initiatives in ministries of Works as in ministries of Health.

11.6.2 Technical Support available from the Private Sector

To manage imported technology requires a combination of abilities: to choose the right equipment from a variety of sources, negotiate terms with suppliers and monitor their performance, plan the effective and safe use of technology, and maintain it cost-effectively. In developed countries these skills are spread amongst various bodies, but in SSA this is not so. Any organization importing technology must develop all the skills and knowledge. In addition the limited size of national markets is a serious constraint to industrial growth, which in turn causes an obstacle to 'back-linkage' ie. the demand for developing specialized technical capacities. Such issues are a feature of being a developing country.

Section 9.1 shows that, within the small industrial sectors of the three case study countries, are very small healthcare technology sectors that are mainly involved in sales and support with only limited manufacturing. Manufacturers sell to developing countries whether they can offer after-sales support or not, and if they do the service is inferior to that offered in developed nations. Long-term equipment expenditure plans are required (Section 11.6.1) on which to develop improved relationships.

Developed nations greatly influence the design of equipment, and donor funding and procurement rules lean towards the cheapest product. It is difficult to find different designs for different work practices, but potential local manufacturers (such as South Africa) are pressurized to conform to international manufacturing standards that are often inappropriate. Appropriate or locally-made products are needed, but they would require some degree of protection, however the World Trade Organization would be unlikely to sanction such a move. The literature showed that technology transfer can actually restrict progress with local development depending on the method of transfer chosen, and developing country governments need more control over such negotiations.

The science and technology community in developing countries is facing the same constraints as the health service for technology management. The literature found that educated transferees had a greater likelihood of success in technology transfer and, in fact, projects were more likely to succeed if they did not take place in Africa.[253]

The problem of importing healthcare technology is not unique, and is not likely to be solved by the health sector alone. Solutions are similar for most technologies transferred, such as: appropriate selection, standardization, adequate supplies of the package of inputs, capacity to use and maintain, and in the long term capacity to produce locally. Policy-makers will need to assess the local capacity to undertake each element, thus close liaison is required between the MOH and the ministries of trade, industry, finance, and development. Thus efforts should be made to integrate initiatives taken to improve the healthcare technology sector with the broader process of developing the industrial sector as a whole. Strategies to strengthen equipment services could develop: local technical capabilities, a demand for specialized services, a stable market, a small financial base to sustain firms and public enterprises, and capacities for manufacturing and research. Thus one consideration in supporting the development of equipment management services should be its contribution to increasing technological capacity in the region.

Technology is not singular, for it consists of technological information, means, and understanding. Thus the question is not whether to import technology or create it at home, but which elements to import and which to obtain domestically. The appropriate choice depends on an evaluation of associated benefits and costs.

Regarding private sector support, Box 11.4 summarizes additional answers to my fourth research question:-

"Can the different experiences in least developed countries offer alternative strategies for the management of healthcare technology?"

BOX 11.4	**Alternative strategies in developing countries for technical support from the private sector (see Section 9.6)**

Current initiatives which work

* local manufacture of physiotherapy and occupational therapy exercise aids, wheelchairs, etc, assemble products from imported parts, and purchase a number of appropriate regional products;
* use 1-2 year supply contracts, with local maintenance capabilities as a condition of contract;
* make use of the support available from other sectors, such as technology centres, University departments, 'middlemen', and facilitator firms.

Initiatives with potential if implemented

* provide equipment suppliers with details of local technical and environmental conditions;
* identify local firms which would be suitable as local representatives;
* develop and support for national equipment expenditure plans to create a stable market for after-sales support;
* develop regional centres of technical information, advice, and possibly maintenance support
* identify local manufacturing possibilities for technologies suited to the region.

11.6.3 Role of External Support Agencies

There are a great many types of donor, and Chapter 10 shows many supply equipment but fewer are involved in projects to develop the healthcare technology sector within developing countries. However, there is little reference to this work in their literature, possibly due to the paucity of healthcare technology engineers involved in these organizations.

Donor policies influence healthcare technology. There have been many trends and fashions in aid that meant changes in donor support for equipment. Their support has often been short-term, piecemeal, and unsustainable. International competitive tender rules are unsuitable for buying complex equipment, and tied aid does not help with rationalization or standardization attempts. Without in-house technical skills, donors are also not Learning Organizations for healthcare technology (Section 11.5.1).

In the three countries studied, support for healthcare technology was rarely addressed as a national development issue, and there were numerous problems with donor support in areas of project design, procurement, technical assistance, training, finance, and future strategies. Project design is especially a problem if there are no in-house equipment management skills in donor organizations and too much emphasis is placed on developed nations' ideas of norms. One failing is that most support goes to the MOH and does not include other sub-system actors such as ministries of Works, local representatives, or local producers.

Some external support agencies, such as GTZ, have in-house healthcare technology skills and substantial effective projects which support the development of healthcare technology management skills and structures in developing countries.[217] Ironically, current changes in the aid field mean that they plan to reduce such work. Most developing countries face bulk healthcare technology replacement, but limited interest is shown by donors in funding this. The future looks bleak unless changes are made. If negotiation on these issues cannot take place, the sustainability of the healthcare technology sector is at risk.

In answer to my fourth research question, Box 11.5 summarizes different experiences regarding the role of external support agencies.

BOX 11.5 **Alternative strategies in developing countries for external support agencies (see Section 10.10)**

Current initiatives which work

* design projects holistically, especially those with a management component;
* develop strong national equipment units which have 'tools', such as national equipment plans, specifications and contracts, policies on turning back unsuitable donations;
* take a long-term perspective, with assistance to national equipment services;
* allow recipients to take the lead role in equipment projects, by establishing a project team that uses the donor and their implementing/procurement agent only as a resource tool;
* make good use of technical assistance, both in terms of long-term placements and short consultancies, together with mechanisms for passing on skills;
* provide training scholarships and develop local/regional training courses;
* establish revolving funds for the supply of spare parts and recurrent supplies;
* develop guidelines for donors when supplying equipment;
* locate the healthcare technology topic within donors' standard operational divisions.

Initiatives with potential if implemented

* reconsider procurement rules so that recipients' wishes can be reflected, and value-judgements and standardization can be implemented;
* implement projects in ways which provide more control to the recipients;
* finance the development of technical and managerial skills for indigenous managers as an integral part of equipment aid packages;
* set aside 30% of support for equipment purchases for its management;
* introduce performance measurements for equipment management activities;
* share data and make it accessible through regional centres and libraries, and support their establishment;
* develop projects which strengthen other players (such as MOW and private sector companies).

11.7 THE CONUNDRUM FOR THE FUTURE

The problem is to develop a strategy that allows health service effectiveness at minimum cost. Not only is it desirable to keep equipment in running order over the short term, but there is a need to develop a capacity to do so increasingly on the basis of local resources. The problem of managing healthcare technology is a small example of the larger problem of increasing industrial capacity in SSA. However, all of this must be achieved against the background of recent independence, colonial inheritance, the AIDS epidemic, globalization, and world market forces.

Health service providers in SSA must manage a vast range of different types of healthcare technology with limited resources. The other actors involved must also play their part in this complex sector. As they face problems at all levels, an holistic view is required as illustrated by (1) the *Technological Systems* approach. Examples of better, more holistic, management philosophies suggest equipment was better managed. Thus (2) an *Institutional Organization* approach is also required. In addition, developing countries are trying to manage technology that has not been designed for them, and good technology transfer principles often have not been applied. Thus, in addition (3) a concern with issues of *Development* is necessary.

My Thesis not only provides an understanding of these three perspectives, it also provides an understanding of the relationship between them. The three perspectives overlap, and focusing on the overlap is important. This Thesis looks at the conundrum of how to manage institutional organization issues (2), within an incomplete system (3), in order to try to get closer to an ideal situation (1). It shows that creative solutions will be necessary for an otherwise intractable problem in developing countries.

The area of overlap between the three perspectives provides the key to answering my first research question:-

"How can the sustainability of the healthcare technology sector be improved in Sub-Saharan Africa?"

The research reported in this Thesis shows that some of the creative solutions required involve moving away from single-denominational activities in a number of different strategic ways:-

* In health services, broaden healthcare technology management activities to include general health staff at all levels, within government and other service providers.
* In the national support environment, expand healthcare technology management activities to other relevant agencies, such as ministries of Works, and Finance.
* In the education sector, build on existing resources for trade and vocational training to cover healthcare technology needs.
* In external support agencies, broaden responsibility for healthcare technology to a cross-denominational team of staff from the divisions for health, social development, engineering, education, etc.
* In the private sector, consider the use of the healthcare technology sector to stimulate (or follow) the development of industrial capacity and manufacturing capabilities.

* In the region, initiate collaboration between ministries of health, finance, trade, industry, and development to develop initiatives, co-operation, and policies for healthcare technology.
* In the field of donor support, broaden strategies to include other players (such as MOW, local producers), new relationships with manufacturers and their local representatives, and regional initiatives.

The research shows that a technology management focus is commonly absent. This is evident from the technology transfer literature, government and donor failure to maximise the life of equipment, and the omission of equipment strategies from the significant sector modifications currently planned (health sector reform, development of district health management systems, and SWAP funding). The development of a technical management capacity and way of thinking requires better integration of engineering expertise.

Thus, in response to my first research question, external support agencies have a very important collaborative role to play with other sub-system actors in order to sustain the healthcare technology sector in developing countries. They are in a position to help overcome all five key constraints identified in this Thesis (Section 11.4). First of all, they can assist with the development of national equipment management units and delivery networks in health service provider organizations, but also in other parts of the national support environment. Second, they can assist with personnel development for a national technical management capacity in developing countries and their own organizations. In these ways both countries and donors will be supporting strategies that will help them to become Learning Organizations.

Not only are developing countries not in a position to finance their healthcare technology sector, with so many other pressing demands on their resources, but donors' actions can add an extra burden. Thus third, donors should contribute to recurrent funding and the on-going maintenance of the equipment supplied. Experts suggest that this could be done through a joint donor/stakeholder controlled foundation for channelling the money. A future area of study will be to identify the real financing requirements for the hardware in the health sector, and look for strategies to pay for it. In addition, methods for undertaking cost-benefit analysis of healthcare technology is required (Section 8.5), as proof to convince financiers of the reasons for investing in healthcare technology management.

A fourth strategy is for donors to collaborate with the private sector in order to strengthen the technical support available. Due to their negotiating power and bulk purchasing, they could pursue new relationships with equipment suppliers to create stable markets and a long-term presence in developing countries (Section 9.3). Each donor has an influential role to play with both international agencies like the World Bank and their own procurement systems, in order to ensure that appropriate locally sustainable equipment can truly be purchased according to value-judgements rather than simply cost. In addition, they should pursue economy-wide policies that would facilitate indigenous technical change through local production of equipment (Section 9.1), together with the necessary lobbying of the World Trade Organization to reflect developing countries' needs. If such positive strategies are adopted at national and regional levels, they can form part of the broader process of rationalizing the manufacturing sector in developing countries.

Lastly, donors should review their development focus. Even though the condition of equipment is bad, staff in the countries studied seem keen to improve their situation. Donors need to stay with these stakeholders and not move in some more-fashionable direction. A serious analysis of healthcare technology management issues needs to be part of the health sector reform process, development of district health management systems, and SWAP funding.

If such strategies are pursued, all parties involved will be better able to manage a *Technological System*, an *Institutional Organization* issue, and a *Development* issue at the same time. Countries and donors will be able to put these combined approaches into their projects, into strategies for the health service, into decentralized management bodies, and into their collaboration with the private sector, thereby making it more likely that the healthcare technology sector will be sustainable.

The *WHO* Global Action Plan on Management, Maintenance and Repair of Healthcare Equipment aimed to raise awareness of the issues and efforts being made at national, regional, and international levels to strengthen the management and planning of healthcare technology services in developing countries.[1] My Thesis contributes to this on-going process.

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Contact Details

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Website: www.dfid.gov.uk
They have a Knowledge and Research programme (KAR) on disability and healthcare technology, website: www.kar-dht.org. For the latest projects being funded use website:www.disabilitykar.net

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit – German government technical aid agency)
Division of Health and Education, PO Box 5180, D-6236, Eschborn, Germany
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Website: http://www.gtz.de/de/4030.htm
Friedeger Stierle is the contact for any GTZ documents on healthcare technology management, and any articles written by Hans Halbwachs.

London School of Economics Library
Website: www.lse.ac.uk/library
This library contains many of the journal articles and source documents from international agencies.

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Website: http://library.open.ac.uk
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United Nations
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World Bank
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ANNEX I: FIELD WORK VISITS

This Annex contains nine tables detailing the visits made during the field work in three case study countries, as part of my methodology (see Chapter 3).

TABLE 3.1 Hospitals visited in Zambia, 1990

Institution	Type	Province	No. of beds[1]
University Teaching Hospital	Government[2]/Central	Lusaka	1,055
Chainama Hills Hospital	Govt/Specialized/Psychiatric	Lusaka	500
Arthur Davison Hospital	Govt/Specialized/Paediatric	Copperbelt	(300 cots)
Ndola Central Hospital	Government/Central	Copperbelt	851
Kitwe Central Hospital	Government/Central	Copperbelt	429
Wusakile Hospital	Industrial/Mine	Copperbelt	248
Nkana Trust Hospital	Industrial/Mine	Copperbelt	45
Kabwe General Hospital	Government/General	Central	509

1. Information from Ministry of Health Statistical Office, June 1990 [70]
2. Given parastatal status.

TABLE 3.2 Additional facilities visited in Zambia, June 1990

Institution	Type	Province
Dental Training School	Government/Central	Lusaka
Instrumentation Training School	Industrial/Mine	Copperbelt
Central National Maintenance Workshop	Government/Central	Lusaka
Kabwe Provincial Workshop	Government/Provincial	Central
Ndola Hospital Workshop	Government/Hospital	Copperbelt
UTH[1] Hospital Workshops	Government[2]/Hospital	Lusaka

1. University Teaching Hospital
2. Given parastatal status.

TABLE 3.3 Additional organizations visited in Zambia, 1990

Organization	Type	Activity
British High Commission/ODA/BDDSA[1]	Donor	Support to the health sector
Japanese International Cooperation Agency	Donor	Support to the health/equipment sector
Royal Netherlands Embassy	Donor	Support to the health sector
Commission of the European Community	Donor	Support to the health sector
Embassy of Finland	Donor	Support to the health sector
UNICEF	Donor	Support to the health/equipment sector
GEC[2] (Zambia)	Private Sector	Equipment Supply/Support Company
ZAL Elevators Ltd	Private Sector	Equipment Supply/Support Company
BEAM Technical Services Ltd	Private Sector	Equipment Supply/Support Company
ZAMOX[3] Limited	Private Sector	Equipment Supply/Support Company
Churches Medical Association of Zambia	NGO	Oversees 30 mission hospitals
Zambia Consolidated Copper Mines	Nationalized	Runs 10 mine hospitals
Medical Stores Ltd	Parastatal	Procurer & distributor for MOH
Equipment Services Corporation (ESCO)	Parastatal	Supplier of plant maintenance services
Central Vehicle Maintenance Workshop	Govt/Donor	SIDA[4] assisted project for MOH

1. British Development Division for Southern Africa
2. General Electric Company
3. Zambian Oxygen Company (Zambian affiliate of the British Oxygen Company)
4. Swedish International Development Agency.

TABLE 3.4 Health facilities visited in Botswana, 1992

Institution	Type	Town
Princess Marina Hospital	Government/Central	Gaborone
Nyangabgwe Hospital	Government/Central	Francistown
Athlone Hospital	Government/District	Lobatse
Segkoma Memorial Hospital	Government/District	Serowe
Selebi-Phikwe Hospital	Government/District	Selebi-Phikwe
Maun Hospital	Government/District	Maun
Jwaneng Hospital	Mine/District	Jwaneng
Deborah Retief Memorial Hospital	Mission/District	Mochudi
Defence Force Clinic	Defence Force/Urban Polyclinic	Gaborone
National Health Laboratory	Government/Central	Gaborone
Oral Health Services	Government/Central	Gaborone
Athlone Dental Clinic	Government/Regional	Lobatse
Segkoma Dental Clinic	Government/Regional	Serowe
Maun Dental Clinic	Government/Regional	Maun
Special Services Unit for the Handicapped	Government/Central	Gaborone
Occupational Health Unit	Government/Central	Gaborone
Family Health Services	Government/Central	Gaborone

TABLE 3.5 Additional facilities visited in Botswana, 1992

Institution	Type	Town
National Health Institute	Government/Central	Gaborone
Botswana Polytechnic	Government/Central	Gaborone
Madirelo Trade Testing Centre	Government/Central	Gaborone
MEMS Southern Workshop	Government/Regional	Gaborone
MEMS Northern Workshop	Government/Regional	Francistown
MEMS Segkoma Workshop	Government/Satellite	Serowe
MEMS Maun Workshop	Government/Satellite	Maun
DEMS Northern Workshop	Government/Regional	Francistown
DEMS Selebi-Phikwe Workshop	Government/Satellite	Selebi-Phikwe
DEMS Nyangabgwe Workshop	Government/Hospital	Francistown
DEMS Maun Workshop	Government/Satellite	Maun
DABS Northern Workshop	Government/Regional	Francistown
DABS Nyangabgwe Workshop	Government/Hospital	Francistown
DOS Northern Workshop	Government/Regional	Francistown
AMMB Engineering Workshop	Mission/Central	Gaborone
MOH Medical Stores	Government/Central	Gaborone

Key:-

MEMS:	Medical Equipment and Maintenance Service, MOH
DEMS:	Department of Electrical and Mechanical Services, Ministry of Works, Transport and Telecommunication and (MOWTC)
DABS:	Department of Architectural and Building Services, MOWTC
DOS:	Department of Supply, Ministry of Finance and Development Planning (MFDP)
AMMB:	Association of Medical Missions of Botswana

TABLE 3.6 Additional organizations visited in Botswana, 1992

Institution	Type	Activity
World Health Organization	Donor	Support to the health sector
NORAD	Donor	Support to the health/equipment sector
Liquid Air Botswana	Private	Equipment Supply/Support Company
Crest Healthcare Technology Ltd	Private	Equipment Supply/Support Company
Safurnco Ltd	Private	Equipment Supply/Support Company
Connor Specialized Supplies	Private	Equipment Support Company
FRAM Group	Private	Equipment Supply Company
Pelegano Village Industries	Private	Equipment Supply Company
International Hospitals Groups Ltd	Private	Hospital management consultancy firm
United Medical Enterprises	Private	Hospital management consultancy firm
RCM Consultants	Private	Hospital management consultancy firm
Computer Bureau	Government	Utilizes specialized equipment
Botswana Technology Centre	Government	Utilizes specialized equipment
Air Pollution Laboratory	Government	Utilizes specialized equipment
Kgalagadi Breweries	Private	Utilizes specialized equipment
Data Processing Ltd	Private	Utilizes specialized equipment
Ministry of Education	Government	Vocational & technical training Divs.
Supplies Directorate	Government	Procurer of office equipment
Ministry of Finance & Development Planning	Government	Finance, tender, & stores rules for Govt.
Ministry of Works, Transport, & Communication	Government	Architects & Plant Engineers for Govt.

TABLE 3.7 Additional central MOH divisions interviewed in Botswana, 1992

MOH Division
Office of the Minister
Medical Services
Technical Support Services
Hospital Services
Primary Healthcare Services
District Management Initiative Office
Health Manpower Planning
Education Development Unit
Continuing Education Unit
Planning Office
Family Health Project
Health Research Unit
Medical Statistics Unit
Supplies
Finance

TABLE 3.8 Organizations visited in Namibia, 1997

Institution	Type	Activity
Windhoek Central Hospital (WCH)	Govt/Central	National specialist referral hospital
Katatura Hospital, Windhoek	Govt/Regional	Regional specialist referral hospital
Okakarara District Hospital	Govt/District	District referral hospital
Otjiwarongo Regional Hospital	Govt/Regional	Regional referral hospital
Central Regional Health Directorate	Govt/Regional	Regional health authority
Medical Technical Workshop, WCH	Govt/Central	Central referral maintenance workshop
Metal Hospital Furniture Workshop, WCH	Govt/Central	Central referral maintenance workshop
Ministry of Works, Transport, & Communication	Government	Architects & Plant Engineers for Govt.
Geiger Electrical & Mechanical Engineering	Private	Equipment Supply/Support Company
Bio-Dynamics (Pty) Ltd	Private	Equipment Supply/Support Company
Siemens	Private	Equipment Supply/Support Company
Rezelec Consultants	Private	Hospital maintenance consultancy firm
Trend Line Economic & Management Services	Private	Hospital laundry consultancy firm
FINNIDA	Donor	Support to the health/equipment sector

TABLE 3.9 Additional central MOHSS divisions interviewed in Namibia, 1997

MOHSS Division
Office of the Minister
Healthcare Services
Specialized Health Services
Planning & Human Resources
Administrative Support Services
General Stores & Supplies
Finance
Medical Laboratory Services
Radiographic Services
Radiation Protection Services