

USING EXPERT SYSTEMS TO SUPPORT AND EXPAND HEALTH DELIVERY STRUCTURES IN DEVELOPING COUNTRIES: A LOOK AT TANZANIA

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Abstract

It is often claimed that Expert Systems (ES) can profitably be used in developing countries where the number of trained professionals in any field is relatively small. This paper gives a brief description of the field of medicine in the Tanzanian context, provides a brief theoretical analysis of an ES, proposes some of the requirements which need to be met in developing an ES suitable for rural based health care delivery on the basis of a recent survey, and examines how Expert Systems could help to support and expand the existing structures providing medical and related care as well as indicating the advantages of ESs. The paper also looks at the problems and conditions which may limit the application of Expert Systems in health services in Tanzania and other developing countries.

BACKGROUND AND INTRODUCTION

The idea of Expert Systems (ESs) to support and expand medical services provision structures in a country, or class of countries, may be discussed very extensively or narrowly depending on the context taken. The context will depend on the overall health care policy adopted by the respective country or countries. In order to discuss this in an enlightened manner, for the case of Tanzania, it would be reasonable to first paint the background of our discussion in terms of the National Health Policy adopted by Tanzania in the light of the prevailing economic and social environment.

The National Health Policy (NHP) in Tanzania is the country's framework for health care delivery with the overall objective to improve health and the general well-being of all Tanzanians with a focus on those most at risk, and to encourage the health system to be more responsive to the health and health-related needs of the people (Mkusa, 1991). Tanzania has developed an impressive six level health services infrastructure. Starting with the lowest, the six

levels are the Village Health Post; Dispensaries; Rural and Urban Health Centres; District and Designated District Hospitals; Regional Hospitals; and Consultant/Specialist Hospitals. This constitutes the national referral system. Table 1 shows how the health delivery system is organised in Tanzania in terms of the six levels and their numerical sizes.

Tanzania has also trained manpower from Village Health Workers and Rural Medical Aides, working in the rural areas, to Specialist Doctors and other personnel working in the regional and higher hospitals within the health sector. Medical personnel trained include Medical Doctors (MDs) and Dentist; Assistant Medical Officers (AMOs); Medical Assistants (MAs); Health Officers (HOs) Rural Medical Aides (RMAs), Health Auxiliaries (HAs); Nurses Grade A; Nurses Grade B; Maternal-Child Health Aides (MCHAs); and Village Health Workers (VHWs). According to Msambichaka, Kilindo, Mkusa, and Kiwara (1994), starting from the fiscal year 1970/71, the number of trained staff increased rapidly to reach 32,410 in 1990 (Table 2). The number of doctors increased from 950 in 1981 to 1,065 in 1983, to 1,115 in 1984 and to 1,160 in 1985. By 1986, there

Table 1: Organisation Of The Health Delivery System In Tanzania

ADMINISTRATIVE LEVEL			HEALTH INSTITUTIONS	
Designation	Units	Type	Units	Person in Charge
Zone	7	Consultant Hospital	4	Medical Superintendent I
		Specialist Hospital	2	Senior Medical Officer in Charge
Regional	20	Regional Hospitals	17	Regional Medical Officer (RMO)
District	104	District Hospitals	129	District Medical Officer (DMO)
Division	360	Health Centre	239	Medical Assistant (MA)
Ward	1963	Dispensary	2600	Rural Medical Aide (RMA)
Village	8500	Village Post	257	Village Health Worker (VHW)

SOURCE: GOT/UNICEF (1990).

were fewer doctors (1000) and their number declined further to 978 by 1990 mainly due to brain drain. From Table 2 it is evident that a remarkable training development was achieved in the rural based personnel, namely RMAs and MCH-Aides.

The national output of medical personnel for the corresponding fiscal years is shown in Table 3.. Msambichaka et. al. (ibid.) observe that the Government of Tanzania, with the support of donors and religious organisations, has increasingly directed its efforts to train more manpower in an environment of hard economic conditions.

Table 2: Health Staff Situation: Selected Years

	1976	1981	1984	1986	1990
Medical Doctors & Dentists	683	950	1115	1000	978
Nationals	356	599	820	846	864
AMOs	193	291	436	250	-
MA's	770	1589	2383	2457	-
RMAs	1049	2691	4601	9391	10102
HOs	156	270	394	570	682
HAs	455	789	1247	1880	3250
NURSE 'A'	1100	1717	2356	2871	3250
NURSE 'B'	3720	6070	7242	7620	9010
MCH AIDES	960	2070	3432	3872	4373

SOURCE: Msambichaka, Kilindo, Mkusa, Kiwara (1994)

Table 3: Health Manpower Output 1977/78 - 1989/90

	77/78	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90
Medical Doctors	47	40	34	56	48	44	55	82	96	65	59
AMOs	35	22	37	31	45	46	25	-	46	-	95
MAs	171	190	210	243	323	252	250	281	276	317	334
RMAs	301	400	423	443	500	410	420	370	393	265	365
HOs	25	40	53	43	44	41	75	55	262	44	55
HAs	45	90	120	143	190	139	140	147	178	163	172
NURSE 'A'	105	126	140	150	345	159	141	123	135	196	135
NURSE 'B'	383	439	429	410	418	498	493	581	610	861	518
MCH AIDES	330	420	417	491	441	401	365	538	413	516	-
TOTAL	1442	1767	1863	2010	2354	1990	1974	2095	2409	2362	1733

SOURCE: Msambichaka, Kilindo, Mkusa, Kiwara (1994)

Performance related to training efforts may best be judged by its impact on service provider to population ratios. Service ratios have remained high (Msambichaka et. al, *ibid*). In 1961 a doctor served 24,819 people but served 27,885 and 26,585 in 1989 and 1990 respectively. In 1991, an MD served 15,000 people. This is still high even when compared with Kenya and Sudan who, respectively, had 9,970 and 10,000 people per an MD.

Ratios related to the rural based service providers have also remained high. In 1961 an MA served 7,759 people while an RMA served 2,419 people. For the RMA not much improvement can be said to have happened as evidenced in Table 4 below. The ratio was 2,427 people per an RMA. The trends examined indicate poor overall training performance in view to reducing service ratios in the whole country and rural areas in particular. These indicate a serious lack of not only experts and professionals in the health sector, but of supporting staff as well.

Msambichaka et. al. further observe that despite the extensive investment made in the elaborate National Health Infrastructure and manpower training, there has not been a corresponding improvement in the health status of the population. To mention only a few, maternal and child mortality rates are still high, life expectancy at birth is still low, child nutrition status is still deplorable, and infectious diseases are still the major causes of morbidity and mortality. This may be attributed to several limitations related to the surrounding economic environment and the way the national health system is organised and managed, as well as inadequate resource management, government structure, and inadequate managerial skills (Mkusa, *op. cit.*).

A few suggestions have been advanced to ameliorate the situation. Hecht and Musgrove (1993) present the call by the World Development Report (1993) to increase public financing of health care services and involvement of Non-Governmental Organisations (NGOs) and the

Table 4: Service Ratios In The Health Sector, Selected Years

	1961	1971	1981	1984	1986	1989	1990
Population per MA	2419	18135	19053	18386	21900	27885	26585
Population per RMA	7759	12605	4229	2935	1788	2287	2427

SOURCE: URT, Economic Surveys, Various Years

private sector in the provision of health care. The number of NGOs in Tanzania is still small but is definitely growing (URT & UNICEF, 1992) and the private sector in the provision of health care is growing (Mkusa, op. cit. and Msambichaka, op. cit.).

These suggestions, while aiming at expanding the national health system, are doing very little, if anything, in the way of supporting the structure to provide the needed health care. The crux of the matter, as has already been demonstrated, is that the number of available medical personnel is far too low even for the current size of the national health delivery system. There is another dimension to the problem, the macroeconomics adjustment policies dimension, in line with the World Bank requirements.

Tanzania started implementing Macro-Economic Adjustment Measures with the National Economic Survival Programme (NESP) in 1981, Structural Adjustment Programme in 1982, other adjustment policies in 1984, the Economic Recovery Programme (ERP) in 1986, and ERP II in 1989 in response to economic disequilibrium. These policies were to use policy instruments like removal of government subsidies to cut down government expenditure (Mkusa and Kigoda, 1992). On the other hand, the majority of the population live in the rural areas with relatively less means to earn income sufficient for substantial contribution to the health care services; and it is not clear which and how much of each resource and funding is provided by which donor and NGOs.

Health care services were, since the 1960's, provided free. Removal of subsidies had hard felt effects on health care delivery services. The health infrastructure deteriorated for lack of repairs and adequate maintenance; acute shortage of drugs and medical supplies grew; and standards of care in the public health facilities fell drastically (Msambichaka et. al, op. cit.).

In the light of this economic and social setting on the one hand, and shortage of medical specialists and other supporting staff on the other, ESs have the potential of being useful to support and expand the national health care delivery system. This paper aims at examining this potential and related problems. It is organised as follows. Section 2.0 presents a brief description

of ESs and justification for their being used in Tanzania. Section 3 concentrates on the conceptual frame and theoretical analysis of ESs, and proposes, on the basis of a recent survey, some of the requirements of an ES suitable for rural based health care delivery. Section 4 examines how ESs may support and expand the national health system as well as the advantages of ESs. Section 5 takes a brief view of problems and limitations related to ESs application in developing countries. Section 6 gives a summary and provides some conclusive remarks.

EXPERT SYSTEMS: DESCRIPTION AND JUSTIFICATION FOR THEIR USE IN TANZANIA

Widman (1995) describe ESs "computer programs (software) that analyse data in a way that, if performed by a human, would be considered intelligent." They have three basic characteristics identified as using symbolic logic rather than numerical calculation in a rule based format; explicit knowledge base understandable to an expert working in a particular knowledge area; and an ability to explain its conclusions with concepts which are meaningful to the user. They may be used for decision support and decision making.

Widman further identifies when these may be useful and presents the following scenario:

- Knowledge required to make decisions is fairly well circumscribed.
- Experts in an area may reach accurate solutions faster than non experts
- There is considerable value in reaching accurate solutions rapidly.
- The data required as input to the decision can be described objectively.

The first point requires the explicit knowledge of diseases and their cures. Major diseases and complicated conditions have been studied and documented (Mwaluko, 1993). The second point is slightly problematic because there are fewer experts and paramedical staff such as MAs and hence RMAs have to be used. The experience of

the “Electronic midwife” (Kaye, 1991) in Malaya and Thailand shows that the knowledge base content of an ES may be equivalent to the basic training given to the respective paramedical and organised into a decision making structure based on real life experience of a seasoned expert in that area, e.g. obstetrics, in the Tanzanian context. On this account, ESs have a potential of being useful in Tanzania.

The third point cannot be overemphasised. ESs provide speed and efficiency in making diagnostic decisions and, in the case of Tanzania, may make a life and death difference in a complicated and dangerous case. The current situation of high incidences of diseases require fast but accurate diagnosis by staff who are not themselves experts in a particular medical field.

The fourth point presents another hitch. ESs, like all computer based systems, make extensive use of the English language. Paramedicals in Tanzania are not well versed in English and a lot of their knowledge of symptoms may well be presented in Kiswahili, the national language. Kaye (ibid.) pointed out that Distress, the ESs developed for Malaysia and Thailand, was translated into a local language dialect. This means that ESs may also be made available in Kiswahili versions. These translations may be used in the remotest parts of the country by who ever speaks Kiswahili, and all workings Tanzanians speak the language.

The current section has looked at what ESs are and endeavoured to justify their use in Tanzania. The following section gives a brief description of the basic conceptual underpinnings of ESs with appropriate adaptation to health delivery in Tanzania.

BASIC CONCEPTS OF EXPERT SYSTEM AND REQUIREMENTS FOR DEVELOPING THEM FOR RURAL BASED HEALTH CARE DELIVERY

ESs are computer programs in which knowledge in a particular area is accumulated and accessed in a way which may be used to draw conclusions, make appropriate recommendations, or to provide a solution to a concrete problem in the respective area. (Birnes, 1990 and Hayes, 1983). In the provision of health services, ESs may be

specifically defined as *computer programs using accumulated knowledge in the health care delivery process to provide solutions to concrete health and health-related problems.* Colin (1995) gives an example of ESs for planning radiation for the treatment of cancer cases.

In broad terms, and in the context of health services, ESs may be defined as rule based computer programs used, together with an interactive user response system, in order to give advice to a concrete health or health-related problem. In order for the system to have adequate functionality, it must have three fundamental components shown in Fig. 1¹.

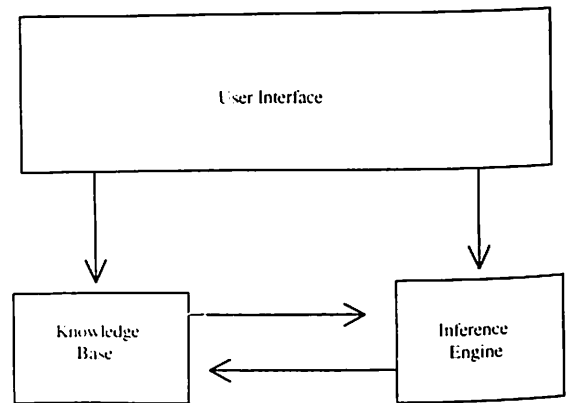


Fig. 1. Simplified structure of an Expert System

The *user interface* is the means by which the user accesses the ES. The *knowledge base* is the standard database of facts and knowledge in the specific area. Finally, the *inference engine* is a device integrating the input data from the user, the goals or objectives specified by the user, and the expert knowledge in the knowledge base.

Let us now say something about the development of ESs. ESs in the delivery of health services have tended to concentrate on high technology health services such as cardiac diseases (Widman, op. cit.) and many validated ESs exist in these areas and especially in advanced countries. The development of these systems have been alongside the same expectations expressed by Mjema (1995). Some of these expectations are that the ESs understand the underlying problems they are intended to assist in solving; the ESs acquire knowledge by themselves; the ESs should be capable of estimating possible

solutions to the problems; and they should be able to deal with partial or incomplete information. These expectations are, as expected, idealised and most of them are far from being achieved. As noted by Mjema (ibid.) and Kaye (op. cit.), the first time an ES is used disappointments are not a new phenomenon.

In order to develop and build an ES for the rural based health providers it is imperative to use the available expert knowledge accumulated through the experience of working in the rural areas. To be meaningful and amenable to use in the Tanzanian rural situation, an ES should be built with the following features. These features are recommended on the basis of the findings from a recent study conducted in a rural based health care delivery system in Igunga District (Mkusa, 1996). The study aimed at studying the overall district epidemiological profile for Igunga on the basis of the common causes of morbidity and mortality at the dispensary in order to determine a basic preventive and curative health services package essential for the district. This was carried out in full collaboration with the District Health Management Team, the District Health Officer, and the registries of the selected government and non-government dispensaries, who maintain detailed morbidity and mortality statistics.

- **Easy but reliable user adaptable.** The various districts in Tanzania have different epidemiological profiles and therefore different health services are required to address the diseases in the patterns exhibited in the profile. The RMA using the ES should be able to adapt it to conform with the profile simply and in accordance with the standard treatment procedures².
- **Able to provide a brief but exact explanation of the diagnosis performed and the treatment suggested.** This is very important in order to verify or check the validity of the diagnosis against known experience. Also, it will ascertain whether the standard treatment protocols are being observed in the suggested course of treatment.

- **Ability to identify and point out whether more information is required in completing the diagnosis of the current case.** Alongside this, the system should be able to point out the information required for the complete diagnosis in a very simple manner to the RMA using the system.
- **Ability to handle probable wrong diagnosis.** The high rates of re-attendances in Igunga district (Mkusa, ibid) has an implication that wrong diagnosis may be a problem to reckon with. The ES should be able to provide alternative and probable diagnosis which may be based on the same information provided by drilling further on some information which may be suggestive of more than one possible conditions.
- **Ability to access in-built treatment procedures or prescriptions suggested by means of its own rules and controls designed and implemented in accordance with the existing government treatment protocols.**
- **Ability to resolve problems related to the provision of more than one health care service required by a particular case.** For example, it is commonly observed that a child may require medication to cure it of a certain disease and dietary advice to address malnutrition problems which the child may be facing. Surely, providing only the curative health service without handling the malnutrition problems is a sub-optimal approach to the health problems the child is having. The ES should be able to address multiple strands health problems which rural based population often have.
- **Ability to handle situations where data and presentation of facts about a case are disrupted, or shaded, by interpretations of the user, the RMA.** The ES should be having a capability to perform what-if analysis to encompass a few very common variations of an input to reflect possible interpretations in the given situation.

- **Ability to learn from the mistakes committed in previous cases.**
- **RMA independent operational rules.** The rules operating the ES should not be dependent on the RMA using the ES but rather they should be based on widely accepted experience, practice, and the standard procedures for providing quality health services. These rules should be independent of the RMA using the ES so that any RMA using the ES under the same conditions should be able to replicate the diagnosis corresponding to the same case.
- **Ability to determine the level to which the current patient may be referred to in case of any referral requirement.** Together with this, the ES should be able to provide relevant referral notes.
- **The ES should allow for a sophisticated programming environment³.**
- **The ES should allow the use of the natural language of the user in order to improve the acceptability of the system.**
- **The ES should have fast execution.**
- **The ES should be memory efficient.**

Actual health related ESs may not meet all these requirements (Widman, *op. cit.*), but if an ES existed, or was developed, such that all of these requirements were met, such an ES would be useful for the developing countries.

This section has concentrated on the conceptual frame of ESs in order to provide a very brief theoretical analysis of an ES, on one hand, and proposed some of the requirements which need to be met in developing an ES suitable for rural based health care delivery on the basis of a recent survey. In being useful, the ESs, in addition to meeting the above design requirements, have to provide support in the existing structure and assist in its expansion. How ESs may do that in developing countries, as well as the advantages of ESs in developing countries, is the subject of the following section.

HOW EXPERT SYSTEMS MAY SUPPORT AND EXPAND THE NATIONAL HEALTH SYSTEM: ADVANTAGES OF ESS

Supporting the national health system will relate to the way the ESs will be working in relation to the existing experts. The current referral system has inadequate specialists at the lowest levels. Specialists are available at the six Consultant and Specialist Hospitals and in a limited number at the Regional Hospitals. The system operates through referrals where patient who cannot be provided with the necessary treatment at a certain level is referred to the next higher level.

One way in which the ESs may support this structure is to reinforce the referral system. Because of lack of manpower, there is a tendency of accumulating facilities where they are mostly used. This is usually at the higher levels of the health infrastructure, i.e. District Hospitals; Regional Hospitals; and The Consultant and Specialist Hospitals. Lower levels, which cover the majority of the population, have poor facilities and equipment and as a result have poor service quality. Patient now go to higher levels even without having been referred, and in most cases for conditions which could be dealt with at a much lower level. In so doing, they cause congestion at these levels resulting in an uneven patient load distribution which affect service quality at these levels.

ESs may reinforce the referral system first by giving the paramedicals and other non specialist staff the ability to make quick and accurate diagnostic and prescriptive decisions. This will enable the lower levels to provide rapid and accurate services as it is required. On the other hand, the ESs may have in-build ways of assessing whether the current level in the referral system may or may not deal with a particular case (Kaye, *op. cit.*). The systems should also have a recommendations mechanism in-build for recommending an appropriate referral. With this mechanism, paramedicals may be able to refer the current patient to the level which may handle the case well. The current referral procedure in Tanzania requires one to go from a particular level to the next level and this may delay appropriate treatment leading to undesirable results.

Thus, the support to the system is seen as **one.** reinforcing the current referral structure by having people treated at the right level and in case of reference, be referred to the correct level; **two.** remove patient congestion at higher referral levels and achieve distribution of patient load as per the respective level's capacity; and **three.** improve service quality all round. Supporting the existing structure is only meaningful if a particular level is made to function properly in a well co-ordinated manner with the other levels.

ESs may also expand the existing structure of providing services. Currently, Tanzania provides curative services through national health programmes such as TB and leprosy programme; Diarrhoea diseases control programme; Aids control programme; Malaria control programme; etc. (Msambichaka, op. cit.). These programmes are in most of the cases bundled and provide services in a narrow band. The use of ESs may expand the service structure by increasing the number and type of curative health programmes; widening the scope of services currently being provided; and relieving doctors, experts, and specialists so that they may concentrate on research and care improvement, especially where human experts are needed.

What has been discussed in this section this far may also be regarded as the advantages which may accrue from using ESs in the provision of health services in developing countries. Presented in an orderly manner, the advantages of ESs in the Tanzanian national health system would be the following:

(a) **Provision of support to the national health system by:**

- (i) reinforcing the current referral structure by enabling the provision of appropriate health care at the appropriate level;
- (ii) removing patient congestion at higher referral levels and achieving even patient load distribution in accordance with the systems capacity;

- (iii) improving the quality of services provided all through the system;
- (iv) enabling the health system to function properly in a well co-ordinated manner.

(b) **Expanding existing health services structure by:**

- (i) elaborating the service structure through increasing the number and type of curative and preventive health programmes;
- (ii) widening the scope of health and health-related services currently being provided;
- (iii) relieving doctors, experts, and specialists of the work load which may be taken by non experts thus allowing them to concentrate on research and re improvement.

The current section has explored how ESs may support and expand service structure in Tanzania. Support may be achieved through reinforcing the national referral structure by having people treated at the right referral level; reducing patient congestion at higher referral levels; and having the structure work in a well co-ordinated manner. Expansion may be achieved by increasing service scope. This has to be done in the context of the national health policy. The section has also presented the advantages of ESs which would accrue to the Tanzania national health system. What are the problems that have to be faced? Which are the limitations that have to be overcome? The following section attempts to answer these questions.

PROBLEMS AND LIMITATIONS OF IMPLEMENTING EXPERT SYSTEMS IN TANZANIA

Discussing problems of implementing ESs in Tanzania or any developing country would not be complete without having to consider problems

inherent within the systems themselves and the limitations imposed on its implementation. These problems are compounded by other problems prevailing in the developing countries.

ESs available for medical and related fields tend to be specialised and focused on one aspect as for example Distress (Kaye, *op. cit.*). Distress was built to monitor foetal distress. This ES was built for a specific condition and specialists in other areas or dealing with other conditions felt left out and the system was not received at the same level of acceptability. Most available systems have been developed for highly specialised areas (Widman, *op. cit.*). In order for these to be used in developing countries, they have to be made available for the common conditions appearing in those countries at the rural levels as well as complex conditions left to the specialist levels. For the rural based paramedicals the immediate problem is that of having more than one system installed and of having the rural medical aide to learn how to function with each one of them. While this is possible, there is the limitation posed by the question of how much time will they need just for learning the systems chosen for implementation?

Related to this is the problem arising due to the fact that ESs do not make decisions but will always help the user to make information available on the basis of what the user has input into the system. The rural paramedical will have to make the respective decisions. This may be a big problem depending on what concept users have of the computer and computer based systems. To many in the developing countries, a computer is a magic machine doing it all and correctly. Having to make decisions when the computer is available will not make sense. The problem is that ESs may lose credibility and the limitation will be the fact that the ESs will not be used as expected despite investments made.

The concept of ESs makes more sense to, and is more acceptable by, people in highly developed countries. I hold a hypothesis that many medical and paramedical staff trained in Tanzania have not heard about ESs and those who have, have not seen one. As an hypothesis this need to be proved. However, as Kaye (*op. cit.*) observed, putting computerised expertise into the hands of rural based medical service providers

could produce results contrary to what the designers of the respective systems had intended. The best RMAs may be intimidated by the machine and harbour the feeling that their patients have been taken away from them. This could mean poor diagnosis and loss of personal touch to the patients. On the other hand, the machine may build false confidence and a feeling, in the worst of the RMAs, that they can handle and tackle situations which are really beyond the scope of their competence. This could mean more deaths or adverse treatment.

Another problem is related to the way the ESs works. Critics of Distress said that the system's question and answer approach is too simplistic. This may be extended to cover the argument that the way ESs operate does not conform to the way medical and other specialists in developing countries would like to view their professions. The approach does not appear to professionally and intellectually involve the user. There is a definite absence of judgement and widespread acceptability and use may be difficult.

Other limitations arise from low financial resource level for the developing countries. In Tanzania the application of computers in the health sector has very few records and these are mainly scanning facilities in private and religious organisations hospitals. This is compounded by poor and intermittent power supply. Most of Tanzania's rural does not have electricity and use solar panels. No electricity means no ability to run any computers. Computers perception and literacy among RMAs is practically non-existent. These need to be trained in basic computer skills and later in expert skill to be able to exploit more of the ESs. They require finances which are not available.

Last but definitely not least, ESs in health services, as noted in previous sections, have almost been exclusively confined to the health problems of the developed countries. Most of the literature available is relevant to ESs in the developed world. There is a very thin literature recording and reporting the experience of developing countries in using ESs for rural based health services. The problem here is the lack of adequate recorded rural based experience with ESs to learn from. Even though ESs are not widely used in Tanzania, some positive and

original efforts have been made (Mjema, op. cit.), from which a few valuable lessons may be learnt. The current paper is an effort in respect of introducing ESs in rural based health services in Tanzania.

SUMMARY AND CONCLUSIVE REMARKS

While Tanzania may not be taken to be a typical representative of developing countries in relation to the use and application of ES, the issues raised here may be used to produce some general remarks.

In the light of the Tanzanian economic and social setting on the one hand, and shortage of medical specialists and other supporting staff on the other, ESs have the potential of being useful to support and expand the national health care delivery system. The use of ESs in Tanzania in particular, is justified by the prevailing explicit knowledge of diseases and their cures; the need to use paramedical rather than expert staff; the need to make speedy and efficient diagnostic decisions; and the possibility of having ESs available in Kiswahili versions.

In order to develop and build an ES for the rural based health providers, it is recommended to use the available expert knowledge accumulated through the experience of working in the rural areas. It is further recommended that an ES should be built such that: the rural based staff using it should be able to adapt it to conform with the epidemiological profile simply and in accordance with the standard treatment procedures; it provides a brief but exact explanation of the diagnosis performed and the treatment suggested; it identifies and points out whether additional information is required in the context of a particular case in a very simple manner; it may handle probable wrong diagnosis and provide alternative and probable diagnosis which may be based on the same available suggesting more than one possible conditions; it operates in accordance with the existing government treatment protocols; it addresses multiple health problems which rural based population often have; and it determines the level to which a patient may be referred to in case of a referral.

Whether or not the use of ESs in a developing country will support and expand health delivery structure will depend on the policy that the country adopts for providing health services. Where a policy is identified, the systems may support the structure through having the various components of the structure working in a co-ordinated manner to eliminate patient congestion and improving service quality. Expansion is supported by the potential of widening the scope of services provided.

This may be hindered by the problems related to the ESs themselves and other economic and social limitations prevailing within the country in question. The fact that ESs are currently confined to high specialisation areas may mean the need to develop common diseases ESs. However, many or an integrated system may be needed. They may negatively affect the work of good rural based health workers and give false confidence to poor ones. The way they function is not necessarily accepted and may seem not to be professionally and intellectually involving the users.

There are also economic and social limitations to reckon with. Low financial resource levels, poor or no electricity supply and extremely low computer literacy may also pose serious problems of applying ESs to the provision of health and medical services in the developing countries.

Last but definitely not least, there is a very thin literature recording and reporting the experience of developing countries in using ESs for rural based health services. The problem created here is the lack of adequate recorded rural based experience with ESs to learn from.

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1. This figure is the simplest possible showing the basic components of an Expert System. A more comprehensive figure is suggested by Mjema (1995).
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