CHAPTER 1

INTRODUCTION

1.1. **Introduction**

A child, today, is the backbone of a nation tomorrow. Every nation should take proper care of the growth and development of her each and every child. For a developing country like India, there are some socio-economic problems in this respect. This work concentrates on the child growth and development (CGD) in the region of North-Bengal districts of India. Around 86% of the people of total population of this region live in rural areas. Most of the geographical areas of the region consist of hill, forest, tea gardens, river beds and Terai area. From Anthropological point of view, wide varieties of people of different ethnicity live in this region, a special characteristic of the region. A significant section of the total population is tea garden workers, a lower socio-economic group. Another significant section lives on cultivation, again a lower socio-economic group.

Health status of an individual is determined by two ecological ends, the internal environment of a child itself including heredity and the external environment or the surroundings. A delicate balance between these two ends is required for the normal growth and development of a child. The major components of the internal environment are the racial and genetic characteristics. Although the racial factor on growth performance of children is somewhat less important than the environmental factors, but it is none the less a significant one. The external environment is governed mostly by food, water, housing, education and sanitation which are controllable factors. However, there are many other factors, too, which are difficult to control e.g. air pollution, radio-active pollution, noise pollution etc. As a matter of fact, this region is almost devoid of these types of pollution, to date. Understanding the importance of 'external environment', it is now termed 'environmental health' [1] by WHO (World Health Organisation). The region under consideration is still lagging behind the marked standard in the environmental health. As a representative example, a study [2] shows that there is an acute problem with standard drinking water supply. This is one of the major factors affecting the growth performance of rural children of this region.

It is demanding to monitor the growth and development performance of children of this region, an unstructured or semi-structured problem. To cover the total region, the total ethnic variables, the total Anthropological variations, lower as well as higher socio-economic groups and to mitigate the lack of proper human experts for the monitoring tasks, a computer-aided consultation system in an expert system (ES) framework is considered to be useful. Starting from MYCIN, a number of Knowledge based consultation systems / expert systems have been reported [3] on medicine such as PUFF, SPE, VM, ABEL, AI / COAG, AI / RHEUM, CADUCEOUS, ONCOCIN, ANNA, BLUE BOX, CASNET / GLAUCOMA etc. But, a very few have so far been reported on paediatrics, e.g. BABY, not to speak of paediatrics of the rural region. It may be mentioned that in developing countries the internal as well as external environment for CGD is very different in rural and urban sectors. Moreover, it should be pointed out that no such comprehensive study has been conducted for foetal and child growth and development for this region in general and for rural areas of this region in particular. In addition, no such knowledge based consultation system has been developed considering the regional characteristics for monitoring paediatric growth and development. It appears that attention should be paid towards solving these problems.

1.2. **Characteristics of the region and the paediatric problem domain** †

The geographical position of the region under consideration has been pointed out in fig.1.1. The main constituents of the total area are : Hills (Himalayan range), Terai area, forests and plain lands. There are a number of rivers originated from Himalayan range causing severe communication problems specially in the rainy season. The total area is 39,864 sq.km. Around 98% of the total geographical area is the rural area. The total population is 1,20,36,292. Around 86% of the total population live in rural areas. 20% of total rural population is of the group 0-6 years. The rural literacy rate (from age group 7 +) is 38%. 45% of total rural population belongs to so-called Scheduled Caste (SC) and Scheduled Tribe (ST), two socio-economic backward classes. SC /ST class is represented by Rajbanshi, Lepchas, Santhals, Rabas, Garos, Oraons, Mundas, Todos, etc. It may be worthwhile to point out that there is a predominance of Mongoloid race among tribal people of hilly region. Most of the population live mainly on cultivation, daily-wage earning workers, tea garden labours and on collection of fruits, vegetables and animals from forests. A significant percentage (46%) of rural population lays below the poverty line (Rs.1200/-per annum). There is one primary health centre per 23 sq.kms. area. The above excerpt has been presented from the Census of India,1991[4].

† This is based on the publication [CSI Communications,May,1997, 15-21; ibid. June, 1997, 21-25] of the author.

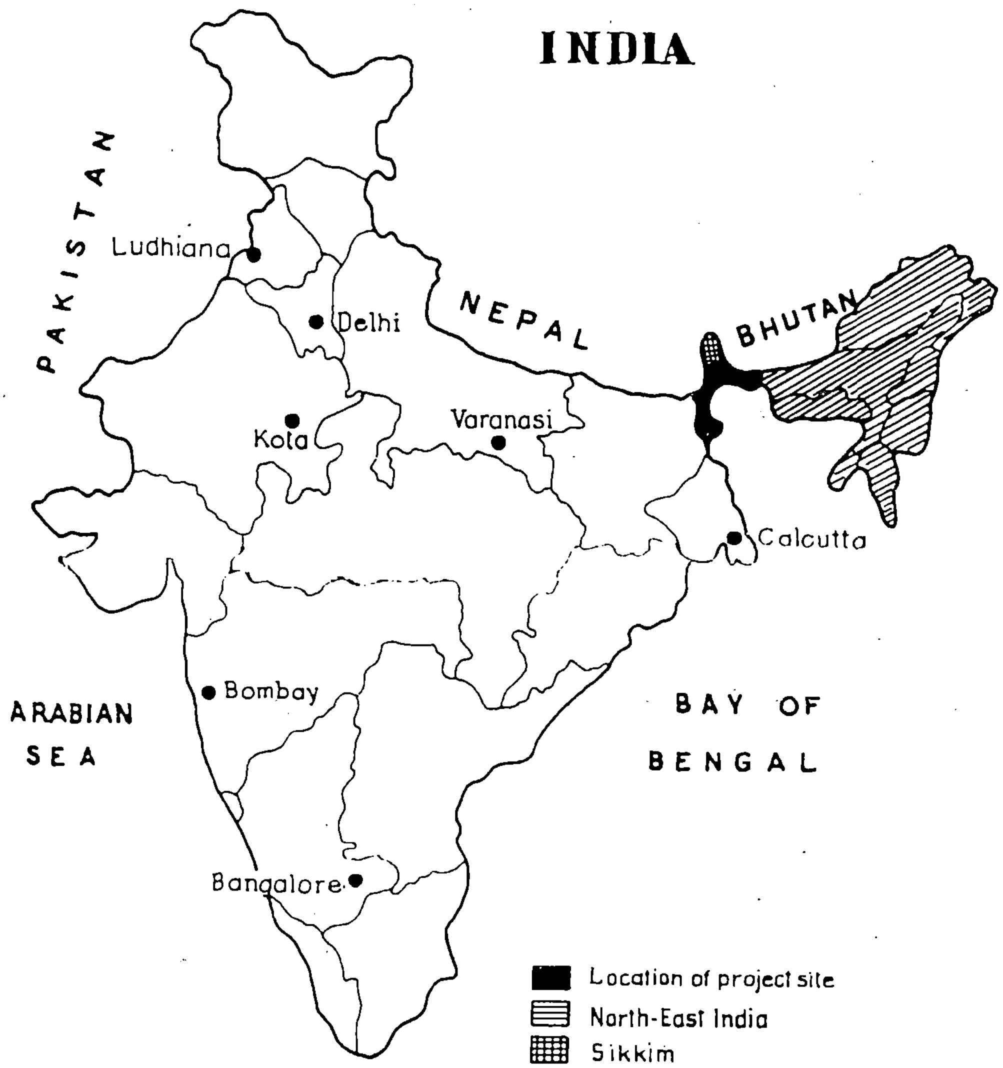

Fig.1.1 India

In addition to the above general characteristics of the region, the following issues may be considered useful. For a proper and correct diagnosis, an expert system expects some initial facts to start with its consultation process. In this respect, there are a good number of sources of inexactness of the region. The elicitation of information from a child and / or from parents / guardians becomes difficult in some situations. The possible identified reasons are (i) the characteristics of the paediatric age group itself, may be true for any region; (ii) illiteracy; and (iii) languages. A child may not be able to supply any relevant information verbally where language development is not adequate. The situation is more critical for 'neonates'. Even, where language development is advanced the situation is not remarkably improved for the paediatric age group. Sometimes, one may notice the lack of adequate consciousness, a possible result of illiteracy and / or ignorance. Sometimes parents / guardians fail to supply the past history of his / her child and even, they, do not note the current problems of their babies. Rather, they do not find enough time for such observations on their children owing to their low socio-economic status; most of the hours they remain busy for small earnings. Sometimes, parents come to doctors with the idea that a doctor should himself or herself find the problems of the child. They do not try to understand the importance of initial history taking for the correct diagnosis by a doctor. This makes the process of diagnosis more critical. To improve the situation, however, a doctor has to take initiative through a set of leading questionnaire as per the paediatric norms. Multilingual characteristic of the region adds another problem to the process. Usually, they use their local languages which may not be understood by a doctor, who is then forced to skip this step of elicitation of information. An ES-designer for the region on paediatric age group has to consider carefully all these uncertainty-concerned issues; the details of which have been presented in **chapter 8**. From the above discussions, one may observe that the expertise, experience and working environments are different in rural areas from urban areas. It might be more important that the pros and cons, and the degree of complexity of developing a knowledge based consultation system for the paediatric domain should certainly be different from adults domain. Even, the disease pattern, drug selection, diet, common rearing technologies are different for different paediatric age groups : Neonates (0-4 weeks), Infants (4 weeks -1 year), Todler (1 year -3 years), Pre-school (3 years -5 years), School-going (5 years -10 years) and Adolescence (10 years -18 years).

The following examples should illustrate the situation.

Case 1 : **Jaundice**

Analysis : If the baby is one or two days old, the possible causes may be ABO or Rh incompatibility, or intra-uterine TORCH infection. The cause of Jaundice at this age group owing to viral hepatites (Hepatities A, Non-A-Non-B etc.) are rare but common for other age groups.

Case 2 : **Not passing urine (Anuria)** for **24-48** hours

Analysis : If the baby is one or two days old, the likely cause is increased environmental temperature with less fluid intake. The significant pathological problems with kidneys are unlikely. For other age groups specially for adults, however, one has to think of the pathological conditions.

Case 3 : **Cardiac diseases**

Analysis : Congenital defects of heart are more common at early age groups (before 5 years); Rheumatic heart diseases are common after 5 years of age; and Coronary heart diseases are common during old age. Moreover, history taking and / or examination procedures in paediatric patients are certainly different from adults.

Case 4 : **History taking typical to paediatric domain**

History may not come from the patient himself / herself but from accompanying persons;

Case 5 : **"Baby is crying since morning" - complaint**

There is no further information available from the patient and / or from the parents / guardians. Here, the doctor has to find out first where the trouble is with the baby, and then what the cause could be, where the sites of the disease might have been pointed out convincingly by an adult, like, stomach pain, earache or headache.

- Family history and social history
  e.g. father-mother relationship, blood discrasias;
- Antenatal, intra-natal and post-natal history;
- Milestones;
- Dietary history; and
- Immunization history.

Case 6 : **Examination procedures to paediatric patients**

Usually, the examinations are done using the following four steps in order :

i) Inspection;
ii) Pulpation;
iii) Percussion; and
iv) Auscultation.

The examination steps should be followed in every case so that it should be methodological. Paediatric patients may be non-cooperative, hostile and resistant to such examinations and therefore, examination steps may have to be altered. For example, very often Auscultation is done before pulpation and percussion when the baby is quite and co-operative before he turns hostile owing to various examination procedures.

For the paediatric patients, there is a special importance of congenital anomalies affecting normal growth and development. In addition, Anthropometric measurements are also typical to paediatric domain.

One can also observe some specialities in rearing technology of the region [2] affecting the growth performance of a child. Even, the preparation of priority list of differential diagnosis might be dictated by the urban vs. rural difference as well as by the Eastern vs. Western difference.

Case 7 : **Diarrhoeal disease**

Analysis : a) Rural : Infective and protozoal diarrhoea are common.
b) Urban : Non-infective and viral causes are highly probable.

Case 8 : **Maculo-Papular Rash**

Analysis : a) Western : Rash due to Adeno virus or allergic cause is more common.
b) Non-Western : Rash due to Measles or Rubella is more common.

In most countries of the world, there is a relative neglect of the children of pre-school age [5]. They are "vulnerable" or special-risk group in any population, deserving special health care. The reasons why the under-fives merit special health care may be stated as follows :

(1) Large numbers : According to the 1991 Indian census, children of the age group 0-6 years constitute 20% of the total population. By virtue of their large number, they are entitled to a large share of health care.

(2) High mortality : In India, 35 to 40 of all deaths occur in children under the age of 5 years. The major causes of death in this age group are diarrhoeal diseases, malnutrition and infection - all preventable. Almost all deaths can be ascribed to failure to make prompt and effective use available means of treatment and prevention.

(3) Morbidity : The first 5 years are full of health hazards - e.g. diarrhoeal diseases, malnutrition and infections diseases (e.g. measles, whooping caugh, tetanus, polio). A very great prevalence of intestinal parasites in this age group is well-known.

(4) Growth and development : The pre-school age period is one of rapid growth and development.

(5) Human resource : Ensuring child health is an investment for the future.

(6) Accessibility : While the infant may be easily reached, the young child (1-4 years) is hard to reach. Special "inputs" are needed to bring the child into the orbit of special health care.

The health care management for under-fives is now undergone through 'under-fives' clinic in India [5]. The aims and objectives of the clinic are set out in the symbol as depicted in fig. 1.2.

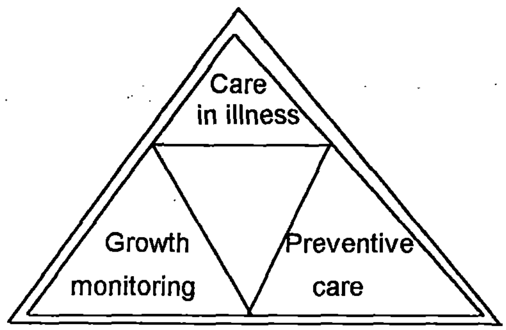

Fig. 1.2 Symbol for under-fives' clinic

The illness care for children will comprise :

(A) Diagnosis and treatment of :

(i) Acute illness;
(ii) Chronic illness including physical, mental, congenital and acquired abnormalities;
(iii) Disorders of growth and development;

(B) X - ray and laboratory services; and

(C) Referrel services.

Preventive care should include :

(i) Immunization;
(ii) Nutritional surveillance;
(iii) Health check-up;
(iv) Oral rehydration;
(v) Family planning; and
(vi) Health teaching.

Growth monitoring is one of the basic activities of the under-fives clinic, i.e. to weigh the child periodically at monthly intervals during the first year, every 2 months during the second year, and every 3 months thereafter up to the age of 5 to 6 years.

Last, but not the least, for a developing country like India, human experts in this field are a scarce commodity. An expert in paediatrics i.e. a paediatrician, sometimes, is overloaded, leading to a scope of wrong diagnosis. The situation may be improved using an automated system. This automated system may also assist a general medical practitioner at rural health centres when confronted by a patient with some unfamiliar symptoms.

1.3. **Needs of the region** +

In a study [6], it has been observed that growth performance of rural children of the region of lower socio-economic group is significantly below compared to the data offered by the National Centre for Health Statistics (NCHS) of USA as well as compared to the data from Indian study [7] for affluent Indian children. The NCHS data is considered 'standard' in many countries including India. So, monitoring growth performance of children on regular basis is essential for this region. In a developing country like India, consulting Paediatricians are scarce especially for rural regions. From remote areas, people are not always interested in coming to urban hospitals or nursing homes or it may not always be possible for them to come because of financial or other reasons. The reasons behind may be manyfold as follows : (1) May it be due to their lack of alertness on the matter, a possible result of illiteracy. (2) May it be due to their lower socio-economic status. It may not be possible for them to spare one working day or so to come to town hospitals as well as to afford this small amount of expenditure for the journey. (3) May it be due to, sometimes, poor road communication. Specially, at the rainy season it is very hard for them to travel 30 to 40 kms to come to town. (4) Even, the Sub-divisional hospitals and the District hospitals are not always well-equipped with such expertise. To meet up the needs of the region, a PC-based consultation system is expected to be useful. From the socio-economic point of view, no better solution is feasible or seems feasible in near future.

Now, here the usage issues of the system should have to be settled. Various aspects of the usage issues are particularly important such as (i) benefits of usage of the system to different potential users; (ii) who will use it and how; (iii) what are / will be the expected reactions of various people in using such a system; (iv) what problems users might face and how to overcome or minimise such problems; and (v) how the question-answer sequence should be tailored.

+ This is based on the publication [CSI Communications, May,1997, 15-21; ibid, June, 1997, 21-25] of the author.

1.3.1. **Levels of benefits**

The figure 1.3. depicts a naive model of benefits with the assumption that benefits will flow automatically if a technological artifact has certain advantageous features [8]. But, however, this assumption is too often manifestly untrue; for instance, a survey results [9] shows that 70% of users of windows 3 found this technological artifact less, rather than more, productive. Hirschheim and Klein [10] cite expert systems, a technological artifact, in which the expected benefits did not materialise. It seems that the link between features and benefits for most applications of technology is weakly threaded and also such links are not automatic.

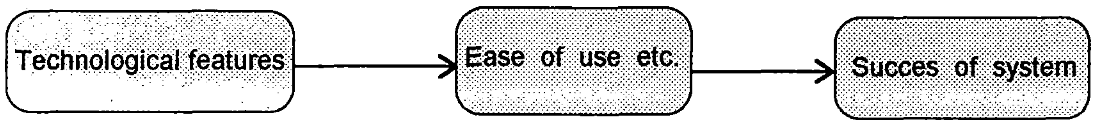

Fig.1.3 A Naive model of benefits.

This is where one has to understand the nature of benefits and how they accrue. Moreover, one has to know i) what constraints there are on achieving each of these benefits; ii) what technological features of functionality and user interface are required in order to yield the desired benefits. To achieve all these Basden [8] suggested that a sound model is required. But there has been little progress towards such models [11]. As Basden points out, there are three approaches to considering benefits namely, the technology centred approach, the practitioner approach, and the senior management approach which have been adopted and there is the need for a fourth, model-based approach.

Considering the technology centred approach most expert systems texts give very little guidance on benefits in use. A typical book on building expert systems by Hayes-Roth et al. [12] looks at what expert systems are : their architecture, types of reasoning, knowledge acquisition, tools for building them, and how to evaluate their accuracy and performance. One may find some discussion on benefits here but the benefits discussed are those accruing to builders, researchers etc. in the act of building the expert system, rather than to those who will use the eventual expert system or be otherwise affected by it. Even books published more recently, such as Benchimol et al. [13], Chorafas [14], Turban [15] and Prerau [16] are similarly weak on usage and benefits. User requirements analysis, which is where one might expect a serious consideration of benefits, is often seen largely as a means of planning the functionality and user inteface of the proposed expert system. The limitation of this type of approach is that it is technology centred, reflecting the view indicated in fig.1.3. While there is some recognition of the importance of the primary user (and hence the user interface), it takes little account of the wider environment in which the expert system will be embedded and especially of the requirements of the organisation.

Considering the practitioner approach for a mention of benefits one must abandon the academic literature and turn to that written for practitioners : guidebooks and handbooks that advise on methodologies for building expert systems. Such books might present a short list of potential benefits and a few case studies, as in Hart [17]. But the approach to benefits is largely ad hoc. What guidance there is tends to comprise a small number of rules and mechanism for knowledge elicitation, user requirements analysis or project planning. For instance, KADS [18] proposes a spiral mechanism for determination and reduction of risk but there is little specific guidance on what benefits to look for in a given situation. It is usually left to the readers to determine what benefits are likely to accrue in their specific situation. While it might not be a rigidly scientific enterprise, the guidance available is not even at the level found in craft industries. There is little understanding of how specific technological features offered by an expert system can lead to benefits and success and conversely little guidance about which features to include in the design in order to achieve the desired benefits. So, while many current workers are highly motivated, it has frequently been found that the actual benefits differ markedly from those expected.

Considering the senior management approach a rather fuller treatment of benefits can be found in the report by the Department of Trade and Industry Enterprise Initiative on Manufacturing Intelligence (DTI) [19]. Aimed at senior managers, it lists over 70 potential benefits that expert systems can offer across a number of application areas such as machinery fault diagnosis and product inspection. However, these lists are not well formed. A subsequent survey of expert systems in use in the United Kingdom (DTI) [20] was a welcome contribution. It presented the results of a survey of a large number of companies in the United Kingdom and gave tables of both 'measurable' and 'less tangible' benefits that were claimed to have accrued as reproduced in table 1.1. These lists are more general than those in DTI [19] and thus offer greater potential. Moreover, with its empirical backing, it is also a considerable advance over the other work. But, as above, it is aimed at senior management.

Table 1.1 **Benefits obtained from use of expert systems, from DTI** [20].

'Measurable'

Time savings
Cost savings
Improved quality
Increased productivity
Improved response times

Reduced skills shortage
Improved administration
Enhanced equipment utilisation
Reduced staff quantity or expertise level
Reduced financial losses
Increased revenues
More customised product offerings
Improved training
Easier maintenance

'Less tangible'

Increased availability of expert knowledge
Better understanding of problems
Increased effectiveness of manager or experts
Better customer service
Additional useful training tool
Better management decisions
Better understanding of technology
Consistency
Enhanced information flow
Increased ability to compete
Faster management decisions
More effective marketing and selling
Better integration with existing systems

Such treatment as found in DTI [19] and DTI [20], giving lists of possible benefits, may be useful in persuading a reluctant or unaware senior management to consider expert systems technology, but three problems remain : i) No attempt has been made to classify types of benefit for the purpose of discussion, not even into the common split of strategic, tactical and operational. ii) It gives no help with understanding which benefits to expect in a given situation, and hence planning for the organisational changes that may be required. iii) It is of little help in ensuring that the desired benefits will in fact accrue.

The lists of benefits in DTI [19] and [20] are non-homogeneous. One can see that some of these benefits are more detailed than others and some of the lower level ones can give rise to more general ones. For instance, 'increased availability of expert knowledge' can lead to 'more effective marketing and selling' or to 'better management decisions'. A more structured approach to benefits is required if they are to be understood. Essentially, a model of benefits is needed that identifies their different types and shows the causality that exists among them. As suggested by Basden, one has to understand the levels of usage for the development of such a model.

1.3.2. **Levels of usage**

Gillies [21, 22] suggests that there are three levels of human computer interaction : physical, task and organisational. The physical level concerns the user interface. The task level, the business tasks that the primary user undertakes while at the user interface. The organisational level concerns the organisational purpose of the tasks. This suggests that benefits which stem from such interaction can also be separated into three types, corresponding to three levels. Thus, for instance, speedier access to functionality would be a benefit of an improved user interface; speedier obtaining of a budget estimate would be a benefit at the task level; and speedier completion of the project proposal, of which a budget estimate is one part, would be a benefit at the organisational level.

Hart [23] discerns three levels at which we can discuss and describe the usage of a technological artifact; these are similar, but not identical, to those of Gillies. He gives the example of using a telephone. At the lowest level, we talk in terms of movements of hand, arm and finger which describe the picking up of the phone and dialling. These are components of the entities engaged in the process and are charactersied by being unable to stand alone. Consideration of the size of people's fingers and of buttons is validly carried out at this level. At the next level we talk in terms of phoning a certain person. We talk in terms of actions which are carried out by or on the entities as a whole - the person, the telephone. But, at this level the actions, while whole, have little meaning in themselves. One does not normally phone a person just for the sake of using the phone. This brings us to the top level, which gives meaning to the action of using the phone. At this level we talk about what we are trying to achieve by using the phone - the maintenance of a relationship, for example.

Let us now understand the difference between the three levels. At the first level we are concerned with technological features, with components that do not stand alone. It is at this level at which we are concerned with the design of such features or components. At the middle level we are concerned with whole entities rather than components and the actions or tasks they carry out. We are usually concerned with the intentional subject. At the top level we are concerned with the role of the entities rather than their actions or tasks. Tasks are reasonably well defined, even though there may be variants among the components of which they are made. They have little meaning in themselves and are carried out in fulfilment of roles, which give them their meaning. Hart characterised the difference between tasks and roles by stating that tasks could be entered in a diary while roles (he gave the example 'Love thy neighbour') could not. Hart maintains that the three levels are irreducible to each other.

The similarity between Hart's and Gillies' levels should be obvious, especially at the task level, but the differences are important. Hart's lowest level concerns any component of the whole entity and, in the case of software, this means not just the user interface but also other features and facilities. While Gillies' highest level is differentiated from the task level by moving from the single user to the organisation, Hart's is differentiated by the addition of meaning or purpose. While it is often the case that the organisation does supply the purpose of tasks so that there is indeed a strong correlation between the two top levels, Hart's top level is not restricted to consideration of organisations. Hart's taxonomy seems more exhaustive and contains less ambiguity.

1.3.2.1. **Usage of expert systems**

One can now understand the use of an expert system using Hart's taxonomy. At the lowest level, we can talk about what we do with parts of the expert system, such as answering questions, using the explanation facility or using the help facility. It is at this level that discussion of the features of an expert system becomes important - what type of explanation it gives, which types of reasoning it employs, etc. This is the level at which most of the papers published on expert systems discourse.

At the middle level we are concerned with the expert system as a whole, rather than its components and features. We are concerned with the individual users and which tasks the expert system supports. It is at this level that classification of expert tasks by Stefik [24] is largely relevant : prediction, diagnosis, planning etc. While consideration of features is largely technology centered, or involves only the primary user's actions at the user interface, consideration of tasks involves the primary user's actions within their immediate organisation.

At the top level, we are concerned with the role the users play in making use of the expert system and the purposes for which they carry out the tasks that are supported by it. In Basden [25] a list of roles was proposed which expert systems might fulfil : consultancy, checklist, program, communication, knowledge refinement, training and demonstration, in an attempt to say something about the application of expert systems. But, one can observe that this list was ill formed and is confusing, since it focuses on the roles the software plays rather than the roles of the human actors. Some of the list are true roles, if translated to the perspective of the human user. For example, by 'communication' it was meant for the clarification and spreading of expertise; and by 'consultancy' it was meant for enabling a person to solve a problem by the provision of expert advice. Both these pass Hart's diary test above and so are roles. But by 'program' it was meant that the expert system shell could be used simply as a language in which to write programs and this does not pass the test : writing a program is a task.

1.3.2.2. **Levels of benefits : towards a model**

If there are three levels at which usage of an expert system can be discussed then it is not surprising if there are three levels of benefits, each pertaining to a different usage level. Basden proposed three levels at which benefits accrue [8] :

a) feature benefits;
b) task benefits;
c) role benefits.

Feature benefits are those advantages that arise from technological features of functionality and user interface. Ease of manipulation can arise, for instance, from graphical user interfaces. An example found in DTI [19] is 'critical items are highlighted'. Task benefits are those which arise from using the expert system to support a task. Examples in DTI [19] include 'fewer changes to schedule' and 'improved visibility of requirements'. Role benefits arise from the effect the expert system has on the roles the user fulfils by carrying out the supported tasks, such as 'improved supplier relations', which in DTI [19] is seen to arise from the two task benefits above.

The list of benefits in the DTI [20] survey can be examined in the light of such a tripartite division. The individual benefits have been classified into feature, task and role benefits in table 1.2.

Table 1.2 **Benefits classified, from DTI** [20]

Role benefits

Improved quality
Increased productivity
Improved administration
Reduced staff quantity
Reduced financial losses
Increased revenues
Better customer services
Better management decisions
Increased ability to compete
More effective marketing and selling

Task benefits

Time savings
cost savings
Improved response times

Reduced skills shortage
Improved administration
Enhanced equipment utilisation
Involvement of staff of lower expertise level
More customised product offerings
Improved training
Easier maintenance
Increased availability of expert knowledge
Better understanding of problems
Increased effectiveness of management or experts
Additional useful training tool
Better understanding of technology
Faster management decisions

Feature benefits

Consistency
Enhanced information flow
Better integration with existing systems

Classification was not always easy, since some interpretation of what was meant was frequently needed. For instance, 'faster management decisions' was assumed to relate to individual decision-making tasks and so classified as a task benefit, while 'better management decisions' was assumed to refer to the quality of management as a whole and hence was classified as a role benefit. Three things are immediately apparent from the classification. One is that there were so few ambiguous cases; this might be evidence for the applicability of the approach. The second is the low number of feature benefits cited; this is what would be expected when a list is business-oriented rather than technology-oriented. The third is the number and variety of benefits at both the task and role levels; this would be expected of a list appropriate to a wide range of business readers. Senior management might be more interested in the role benefits and potential primary users might be more interested in the task benefits.

Benefits that relate to the organisation as a whole tend to be role benefits and those that relate to part of the organisation tend to be task benefits. But, this is not always true. 'Reduced skills shortage', for instance, can be applied across the whole organisation but skills are used in the carrying out of tasks.

While it is useful to be able to classify benefits into three sets, there is indication of some form of causal, or at least enabling, link between them. Feature benefits can lead to task level benefits, which can in turn lead to role level benefits as shown in fig.1.4.

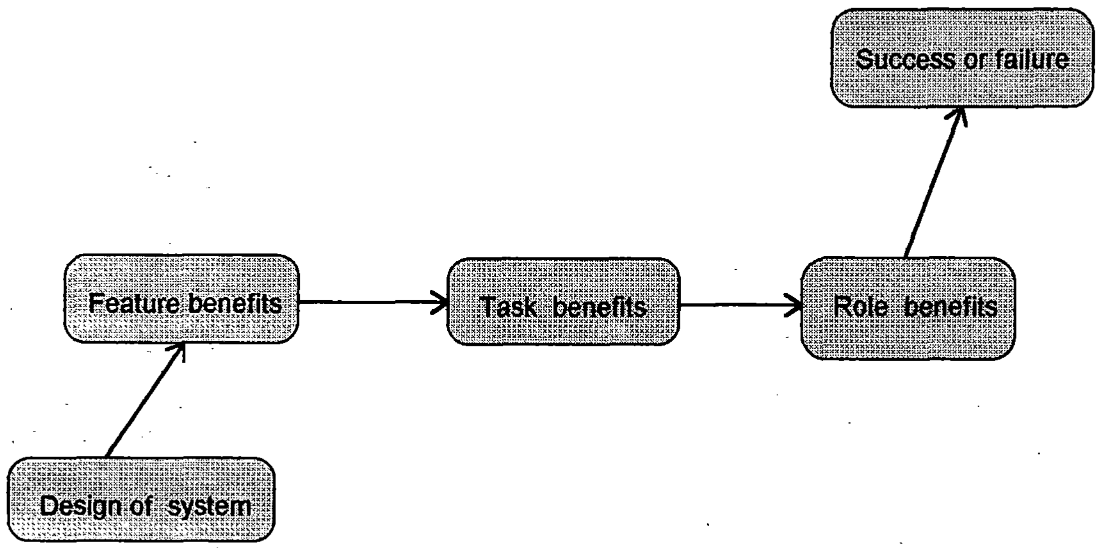

Fig.1.4 Three levels of benefit

It is role benefits, rather than feature and task benefits, that are a determiner of the success or failure of a system since, as discussed above, tasks and features find their meaning only in the context of a role.

Two observations need to be noted here about the links. The first observation is that the links are many-to-many rather than one-to-one. Thus, a feature benefit can enhance a number of tasks and a given task may require several feature benefits as shown in fig.1.5. For instance, given the DTI list, better integration with existing systems would increase availability of expert knowledge, enable the user to respond faster and allow faster decisions, but faster decision-making would also require consistency and would benefit from enhanced information flow. Similarly, a task benefit can support a number of roles and a given role may depend on several tasks. So faster decision making would enhance both productivity and customer service, while the latter would benefit not only from faster decision-making but also from more customised products and increased availability of expert knowledge.

The second observation is that, though there is some causality in the links shown in fig.1.4 and fig.1.5, it is not deterministic. Some links may be fully causal while others are merely enabling. Further, there are other factors which influence the operation of each link, such as working practices, organisational norms and attitudes of users or others around them. For instance, it is often found that feature benefits give rise to significant dis-benefits at the task and role levels [8].

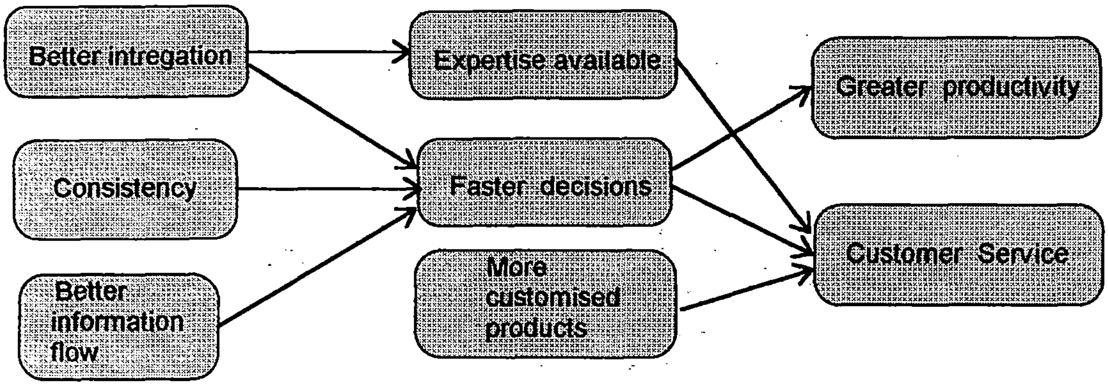

Fig.1.5 Three levels of benefits in DTI study

1.3.3. **Present system**

It is a fact that an automated knowledge-based consultation system should be useful for constant monitoring of the growth and development performance of children of the region of North-Bengal districts of India simply because it is not feasible to appoint one paediatrician for each rural health centre of the region whereas the proposed system can be operated by a general medical practitioner. This happens to be the primary benefit of such a system expected to mitigate such expertise, obviously to a restricted sense. Once, this PC-based consultation system is installed at remote health centres, the system is expected to assist the general physicians who are not expert in paediatrics. This system is also expected to assist the general physicians, not expert in paediatrics, working at sub-divisional / district hospitals or engaged in private practice. As a worst case, it may not be possible to install such a PC-based system at different rural health centres. In such a situation, this consultation system may be carried with a mobile medical unit having a personal computer (PC) along with the required storage cells or a generator unit for power supply. This mobile medical unit may, at least, be controlled by a general physician. Worthwhile to note here that medical students work with the expert guidance at various fields during their undergraduate / training courses. When appointed at a rural health centre, this system should certainly work as a companion of theirs. Even, the system may be used by a paediatrician looking for a second opinion. The overloading problem of an expert is expected to be relieved to some extent by the use of this automated system. It may also be used by the medical students as a 'training kit'. In all such situations, one may observe the increase of the level of accuracy and confidence during an interaction with a child under treatment. We also certainly expect a better patient management and treatment planning. It is now easy to observe the tangible benefits of the society as well as of rural people. In most of the situations, the rural people need not come to distant-located hospitals, which should save time, money and harassment.

From the above discussions, it is evident that the common users of the system will be the medical professionals who may not have any exposure to AI and expert systems technology. Even, they may not have any basic training on computers and computations. However, such types of introductory ideas on computers and computations are now being introduced in school levels in different institutions. Possibly, the by-product of the above situations is the lack of motivation and / or a kind of inertia to maintain the traditional systems. The situation should certainly be improved by the co-ordinated efforts from some expert groups arranging seminars, special talks for such users. This curriculum should contain the basics of computers and computations; what is AI and expert systems technology - the usefulness and limitations of this modern technology; and lastly, an overview of the present system. Hopefully, one-week intensive course would be adequate. In the initial phase of such use, an easy developer-user interaction should certainly be encouraging to minimise such problems.

Let us now have a look on the reactions of various people in using such a system. Various people include : government policy, doctors, patients, and parents/ guardians. It should be noted here that different funding agencies of Govt. of India encourages research projects for the development of such automated systems using AI and expert systems technology under human resource development schemes [26]. Doctors are also taking interests in developing and using such automated systems within the confines of the present status of AI and expert systems technology in collaboration with computer professionals. Paediatric patients may not have any adverse impact on this. Rather, they may be attracted by the colourful screen of the computer what may assist a doctor to manage a child during examinations. Usually, parents / guardians are motivated by the advice from doctors. If the doctors are really motivated in using the system, there should really be no such adverse motivation build-up.

The question-answer sequence should be tailored : (i) to the needs of the region, (ii) to the users' level, and (iii) to the nature of the paediatric problem domain. If the users were para-medical staffs, obviously, question-answer sequence should not have any knowledge from the intimate areas of paediatrics. On the contrary, as the users are medical professionls having basic degree of medical science or undergoing such type of course, the sequence should be as per the paediatric norms. The question-answer sequence should certainly be governed by the age-group property : Neonates, Infants, Pre-school, School-going, and Adolescence. Few examples are given below.

Case A : **Neonates**

During this period, the importance of antenatal, intranatal and immediate postnatal history are very significant along with the family history and the history of maternal diseases. The congenital deformities are also common at this age group. These issues are to be taken carefully during question-answer sequence.

Case B : **Infants**

Milestones and immunization history along with the birth history are important at this age group. Anthropometric measurements are also very significant during this period.

Case C : **Adolescence**

Psychological and behavioural disorders should be taken care of during the question-answer sequence.

It is now easy to view the expected benefits of our proposed system at per the tripartite division : feature benefits, task benefits, and role benefits as shown in fig.1.6.

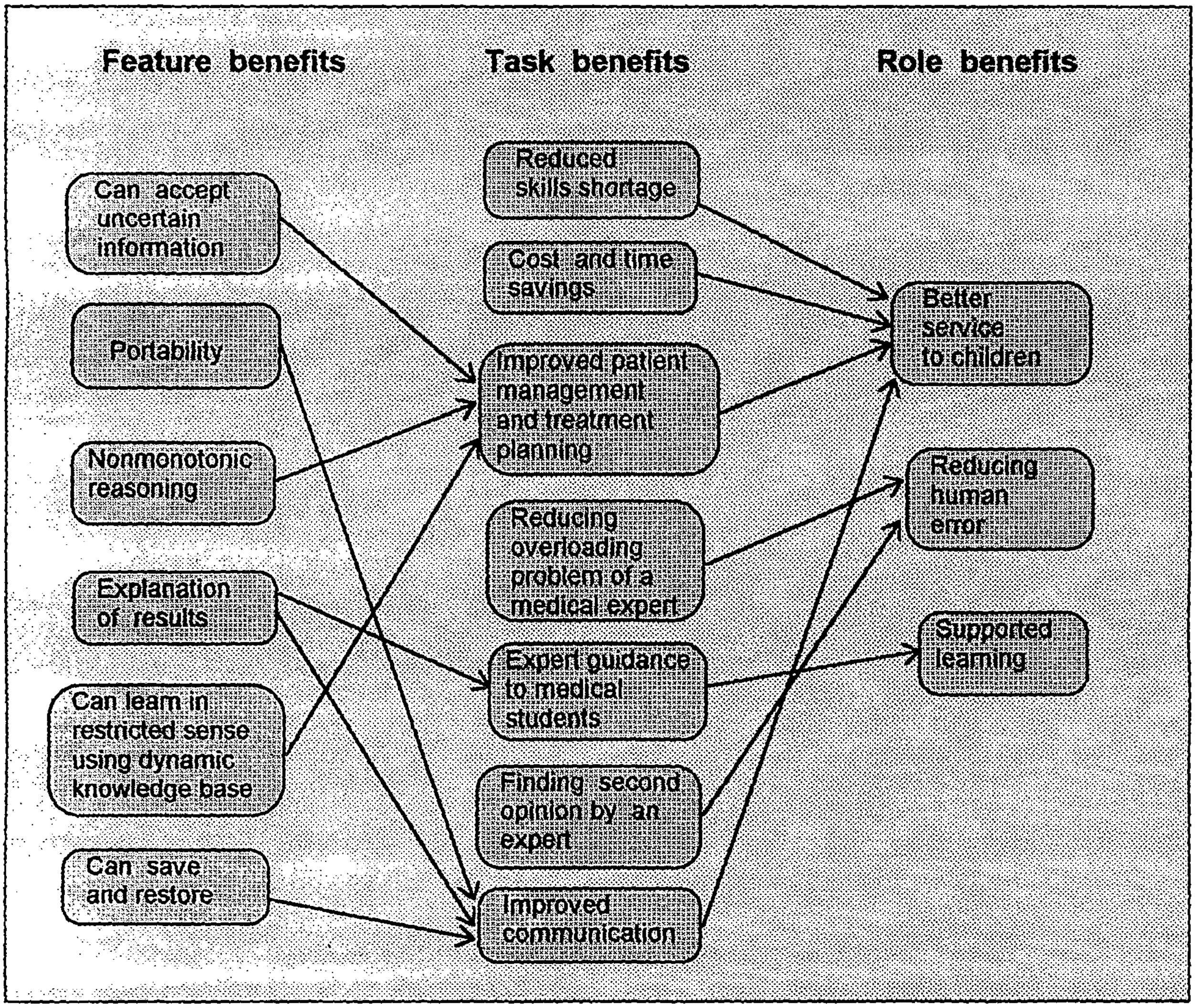

Fig.1.6 The levels of expected benefits in use of our proposed system

1.4. Aim of the work

The aim of the present work is to first study the status of the foetal as well as child growth of a region of lower socio-economic status, North-Bengal districts of India. Next, a knowledge based consultation system for monitoring the growth pattern of the paediatric problem domain has been planned to meet up the needs of the region. This we intend to do in steps. The status of foetal growth is studied first. Next, the status of child growth of the age range 1 month to 5 years has been studied. Lastly, we concentrate on the development of a knowledge based consultation system for monitoring purpose. The emphasis has been on different potential issues such as (i) why it is an expert system domain, (ii) what requirements the domain lays on an expert system, (iii) knowledge representation, (iv) management of inexactness associated with the problem domain, (v) required expert system architecture, (vi) selecting an appropriate expert system tool, and (viii) usage issues, etc. The process of building an expert system is inherently experimental [27]. The applicability of different potential issues pointed out above has been studied in different steps of the development following the prototyping approach of system development. Expert system development is the first and foremost software engineering [28]. Therefore, it is planned, during the development stages some software engineering issues are to be studied as well.

1.5. Summary of the work

The scheme of presentation is as follows :

A) Chapter 2 contains the results of our studies on foetal growth performance of the North-Bengal districts of India. A comparison has been made between lower socio-economic mothers vs. higher socio-economic mothers. A comparison has also been made between North-Bengal results vs. Western results (Montreal, Baltimore, Portland and Britain).

B) Chapter 3 contains the results of our studies on growth performance of children of rural region of North-Bengal districts of India. Comparisons have been made among the results of this study, NCHS data and the results of the studies conducted among the affluent Indian children.

C) In chapter 4, we intend to discuss our findings related to factors affecting the growth of the children of this region. The lack of proper drinking water supply and the feeding practices in infants have been identified primarily responsible for affecting the growth performance of children of the region.

D) Chapter 5 contains two important issues : (i) why it is an expert system domain; and (ii) what requirements the domain lays on an expert system. This chapter initially discusses, in brief, what is artificial intelligence and expert systems, categories and application areas of expert systems, components of a typical expert system, general desirable features of an expert system, different stages of an expert system development, rule based vs. model based system etc. and lastly, the above mentioned two important issues (i) and (ii) have been presented.

E) In chapter 6, we have discussed different schemes for knowledge representation - their merits and demerits. We have also discussed the relative suitability of the methods in context to the present problem domain.

F) In chapter 7, we have presented our prototype system (version 1.0, version 1.1 and version 1.2). In the process of such presentation, we have explained the concept of prototyping and prototyping cycle of system development. A comparison between phase refinement vs. prototyping has been presented. The development stages from one version to the other have also been explained.

G) Chapter 8 deals with the issue of inexactness in detail. The sources and nature of inexactness have been identified and discussed with examples. A suitability analysis of different methods of handling inexactness which seem(s) to be most sympathetic to the problem domain at our hand has been provided.

H) In chapter 9, we have presented the ideas on a research direction incorporating an outline of some fuzzy concepts in paediatrics in order to design a powerful expert system which needs to take into account some fuzzy concepts along with other types of inexactness of knowledge. Our prototype system(version 2.0) incorporating inexactness in the form of fuzzy terms has been presented here.

I) Chapter 10 deals with the issue of selection of an appropriate expert system tool. A detailed study has been provided here among three types of tools : AI-languages, tool kits and shells.

J) Chapter 11 presents a fuzzy knowledge based neonatal resuscitation management system. Performance evaluation of the system has been presented. Our conclusions are also summarized.

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