INTRODUCTION

1.1. **Introduction**

A child is the 'future' of a nation. Every nation should take proper care of her each and every child. In this respect, there are some socio-economic problems which obviously varies from country to country. The degree of complexity of the paediatric domain varies with adult vs. child, urban vs. rural, Eastern vs. Western, as well as developing vs. developed countries. The incidence of low birth weight, mortality and morbidity rate etc. widely varies from country to country; and even this account varies from one zone to the other within the same country. **Chapter 2** of this thesis has been devoted to have an account of the global as well as Indian scenario; and this account demands much more attention towards the paediatric domain.

The total paediatric age group is subdivided as: Foetal (Conception - birth), Neonates (0-4 weeks), Infants (4 weeks -1 year), Toddler (1year -3 years), Pre-school (3 years -5 years), School going (5 years -10 years) and Adolescence (10 years -18 years). It should be pointed out that the disease pattern, drug selection, diet, common rearing technologies are different for different paediatric age groups. The following examples should illustrate the situation.

Case 1 : **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 2 : **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 3 : **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 hepatitis (Hepatitis A, Non-A-Non-B etc.) are rare but common for other age groups.

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. Here the doctor might has to seek for the following informations.

- Family history and social history
  e.g. father-mother relationship, blood dyscrasias;
- 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) Palpation;
iii) Percussion; and
iv) Auscultation.

Inspection is the act of visual examination of the external surface of the body as well as of its movements and posture. Palpation is the process of examining by application of the hands or fingers to the external surface of the body to detect evidence of disease or abnormalities in the various organs. Percussion is the process of use of the finger tips to tap the body lightly but sharply to determine position, size, and consistency of an underlying structure and the presence of fluid or pus in a cavity. Auscultation is the process of listening for sounds within the body, usually to sounds of thoracic or abdominal viscera, in order to detect some abnormal condition, or to detect foetal heart sounds.

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 palpation 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. 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.

Considering the pre-school age group, it may be mentioned that in most countries of the world there is a relative neglect of such children [1]. 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 infectious 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 [1]. The aims and objectives of the clinic are set out in the symbol as depicted in fig. 1.1.

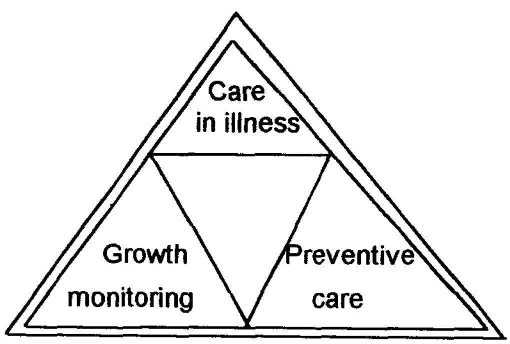

Fig. 1.1 Symbol for under-fives' clinic.

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. In this part, developmental activities are also considered (see Appendix A).

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. The external environment is governed mostly by food, water, housing, education and sanitation which are controllable factors. Understanding the importance of 'external environment', it is termed 'environmental health' [2] by WHO (World Health Organisation). For the proper development of a child we have to improve the 'environmental health'.

As a representative example, let us have a look on the status of North-Bengal districts of India [+].

1.1.1. North-Bengal Districts of India

The geographical position of the region has been pointed out in fig.1.2.

The total area is 39,864 sq.km. Around 98% of the total geographical area is the rural area. At per the 1991 Indian Census [3], 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%. 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 region is still lagging behind the standard in the environmental health. As a representative example, a study [4] shows that there is an acute problem with standard drinking water supply.

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

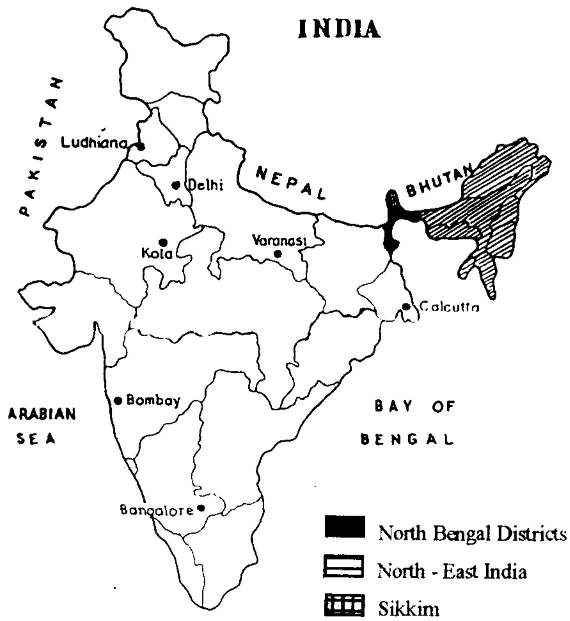

Fig. 1.2. INDIA

In a recent study [5], it has been observed that there is a marked difference of foetal growth in terms of birth weight for North Bengal region of India compared to some Western studies as shown in fig. 1.3. This was conducted on lower as well as higher socio- economic groups which comprise 858 and 1169 live born babies respectively using classical technique of measuring weights after birth. It is evident from the fig. 1.3 that the birth weights of fetuses of mothers of lower socio-economic group (LSEG) are much lower than the mothers of higher socio-economic group(HSEG).

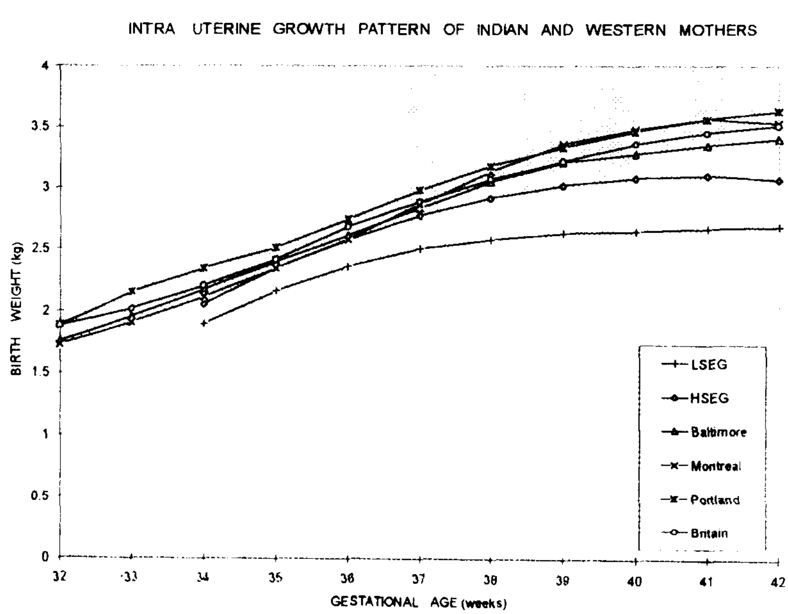

Fig. 1.3. Intra-uterine Growth Pattern of Foetus of Indian and Western Mothers.

Next, one has to find out the status of growth performance of children after birth. The data offered by the National Centre for Health Statistics (NCHS) of USA [6] are considered standard for child growth in many countries including India. The NCHS standard does not differ significantly from the Harvard standard in use earlier, as far as under fives are concerned. There is some difference with respect to the older age groups. In 1991, Agarwal et al. [7] conducted a study amongst affluent Indian children of seven different cities of India. From their studies, Agarwal et al. [7] did not find any significant difference from NCHS standard at least for the Indian regions, they considered. A study has been conducted recently [8] to find out the growth pattern of the rural children (0-5 years) belonging to poor socio-economic condition. The sample size is 1181 for girls and 1470 for boys from lower socio-economic status. Their observations are represented in figs.1.4 and 1.5 for growth in terms of weight. Observations on height, head-circumference and chest circumference are available from ref. 8. It is evident from the figures that the growth performance of children of lower socio-economic group is poor compared to NCHS and other data.

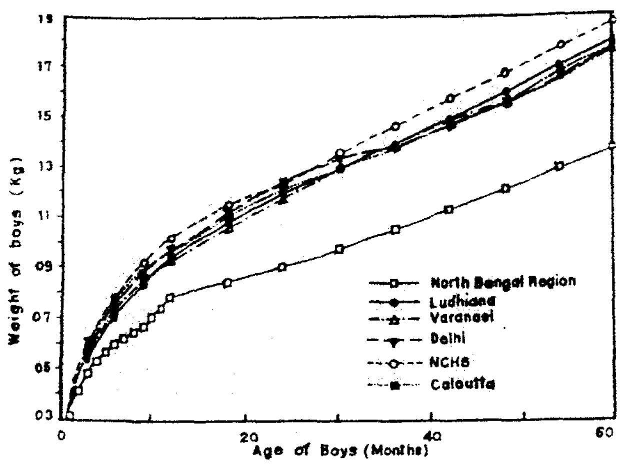

Fig.1.4. Weight of boys of lower socio-economic group and its comparison with reference values.

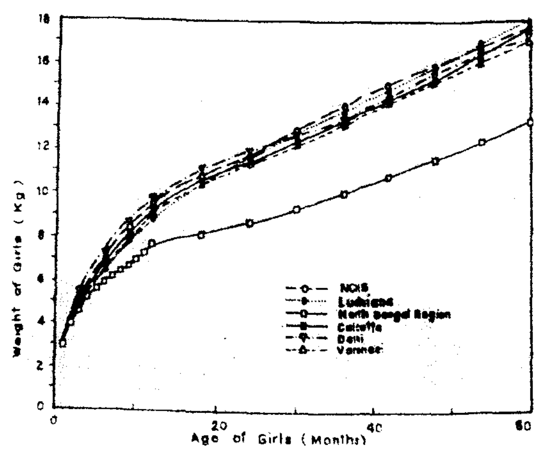

Fig.1.5. Weight of girls of lower socio-economic group and its comparison with reference values.

It is evident from the above facts and figures that this region is lagging behind the standard in the paediatric growth and development. This type of picture or even more discouraging pictures one may have from the facts and figures described in **Chapter 2**.

It is demanding to consider two matters concurrently : (1) improving the environmental health, and (2) improved health care management. Regarding the first matter different developing countries including India are taking actions by providing drinking water at per WHO specifications as well as supplying supplementary food to them. This work mainly concentrates on the second issue i.e., improved health care management. For the proper paediatric care the role of a paediatrician is pivotal. From the table 2.14

(Chapter 2) we get a picture of the availability of paediatricians working in rural regions of India what is not at all satisfactory. They are really a scarce commodity at per the requirements in general and specially for rural region of a developing country like India. To cover the complexity of the domain as well as mitigating the scarcity of domain experts one may consider an automated consultation system in an expert system framework as an alternative. Starting from MYCIN [9], a good number of attempts have been made to develop such expert systems in medicine with their relative success and failure. We may cite here example like BABY [10], a system for the paediatric domain, but, however, to the best of our knowledge, not so much of the issues relating to paediatric health care management have been addressed in this context. In this work an attempt has been made towards the development of a consultation system for the domain in an expert systems framework to partially meet up the requirements of the paediatric domain.

1.2. The Rise of Medical Informatics[+]

If the physiology literally means the 'logic of life', and pathology is the 'logic of disease', then medical informatics is the logic of health care [11]. It is the study of the way, we think about patients, and the way the treatments are undertaken. It is study of how the medical knowledge is created, analysed and are shared among professionals and applied to the medical domain. Ultimately, it is the study of how we can establish proper health care management.

Although the term 'medical informatics' appeared in the literature in around 1973, but the study is as old as when a doctor examined a patient, first recorded the findings and later used those information to his/her next patient. Medical informatics is as much about computers as cardiology is about stethoscopes. The field of medical informatics is concerned with computers, communications, doctors, patients, nurses and medical knowledge. The study of informatics in the coming century will probably be as fundamental to the practice of medicine as the study of anatomy has been this century.

The interests, role and applications of information sciences in medicine are growing exponentially this decade, the Internet decade, compared to the last decade of Eighties. Not only the patient records are being stored and retrieved but it covers everything from the manner in which evidence is used in clinical decisions, how one decides which piece of knowledge is relevant to a particular situation, and ultimately to how medical knowledge itself is created. Another dimension has been added with the introduction of world wide web (www) and Internet services. It has resulted some new techniques, concepts and ideas (e. g. telemedicine).

[+] This is based on the publication [Int. AMSE Conf. (CMSC-99), Jaipur, India: 1-3 Dec. 1999 (to appear)] of the author.

Summarily, medical informatics use more or less all methods of information technology such as acquisition, processing, control, interpretation, transformation, transfer and presentation of data for medical purpose. Networking of large health care groups, linking of hospitals and research centres, transfer of diagnostic and therapeutic information, video conferencing, application of hospital information system, expert systems for diagnosis, image analysis and pattern recognition for pathological investigations, telediagnosis and telemedicine, virtual reality training for surgical applications and modelling of brain for psychophysiological and individual animations will be useful and integral part of biomedical technology in the 21^{st} century.

Let us now have a look on the the issues (i) Telemedicine, (ii) Internet and world-wide-web, and (iii) Artificial Intelligence in medicine (AIM) contributing to the advancement of medical informatics.

- **Telemedicine**

The essence of telemedicine is the exchange of information at a distance, whether that information is voice, an image, elements of a medical record, or commands to a surgical robot. It seems reasonable to think of telemedicine as the communication of information to facilitate clinical care.

At its inception telemedicine was essentially about providing communication links between medical experts in remote locations. The health care system, however, is clearly inefficient because of its poor communication infrastructure and telemedicine is now seen as a critical way of reducing that cost. One estimate suggests that the health system in the United States could save $30 billion a year with improved telecommunications [12]. Consequently, telemedicine has now become an important subject for research and development.

Currently, the press is flooded with articles about the information superhighway, the internet and the rapid growth in the use of mobile telephones. Telemedicine is often presented in the guise of sophisticated new communications technology for specialist activities such as teleradiology and telepathology.

Telephone systems can make significant improvements to the delivery of care. For example, follow up of patients is often possible on the telephone. Rapid communication of hospital discharge information using existing electronic data transfer mechanisms is beneficial for general practitioners. Perhaps more interestingly, inexpensive voice messaging systems can deliver simple but powerful services over existing telephone networks. A voice mail system can reduce both tardiness and complete forgetting. As more patients get access to electronic mail, this will offer further avenues for innovative health services. Already in some populations, access to electronic mail is high. All these points suggest that the potential for the clinical application of communication technologies is indeed great, but equally that there is much still to learn. In particular, the relation between telemedicine and informatics needs to be explored in greater detail. Informatics focuses on the use of information, and telemedicine on its communication.

- **Internet and World-Wide-Web**

The internet is essentially a network of networks. It is an open and unregulated community of people who communicate freely across an international electronic computer network. The number of medical sites joining the internet increases monthly, as does the number of information resources available on it.

At present, the internet is in a phase of massive expansion, with growth rates of well above 10% per month. This is largely because, where before it's value for most people was marginal, it now offers communication and information services thet surpass those possible by plain telephony or television. As more of these information services become available, even more people are being persuaded to join.

For a long time, users communicated on the internet using electronic mail. This essentially allowed users to exchange text messages across the globe, usually in a matter of minutes. However, it was probably the advent of the World Wide Web that triggered the recent growth of the internet. Essentially a set of software standards, Web programs allow users to navigate rapidly across the global internet. Here they can view a bewildering variety of information, from the bizarre and inaccurate, to the most up-to-date information available from scientific bodies, newspapers and academic journals.

There is now good evidence that such services are valuable and in constant use. The OncoLink information resource, for example, provides oncologists with up to date trial and treatment information, as well as acting as an educational resource for cancer patients and their families. OncoLink was reportedly accessed 36,000 times in March 1994. The figure for November 1995 was 7,51,261 accesses.

Perhaps just as important as the ability to view information, the Web provides methods for anyone to publish information, and make it immediately available across the globe. This is achieved through a simple set of document standards that allow users to create electronic documents using text, image and video. The quality of these documents is now so high that the Web is used, for example, by several medical educational institutions. But, however, there are some problems with quality and other related issues what have been discussed in chapter 4.

- **Artificial Intelligence in Medicine (AIM)**

Although telemedicine, Internet and World-Wide-Web help (i) acquire knowledge, (ii) advice through communication channels etc., but, however, it is required to have in-house expertise for routine paediatric care management. In this respect, AI and expert system technology can contribute to the paediatric domain.

In the year 1984, Clancey and Shortliffe [13] provided the following definition of AIM :

> 'Medical artificial intelligence is primarily concerned with the construction of AI programs that perform diagnosis and make therapy recommendations. Unlike medical applications based on other programming methods, such as purely statistical and probabilistic methods, medical AI programs are based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations'.

But, however, today the above definition would be considered narrow in vision and scope. At per the state of the art AIM has already contributed much more than defined by Clancey and Shortliffe.

AIM systems are by and large intended to support health care workers in the normal course of their duties, assisting with tasks that rely on the manipulation of data and knowledge. An AI system could be running within an electronic medical record system, for example, and alert a clinician when it detects a contraindication to a planned treatment. It could also alert the clinician when it detected patterns in clinical data that suggested significant changes in a patient's condition.

Expert or knowledge-based systems are the commonest type of AIM system in routine clinical use. They contain medical knowledge, usually about a very specifically defined task, and are able to reason with data from individual patients to come up with reasoned conclusions.

There are many different types of clinical task to which expert systems can be applied :

- **Diagnostic assistance**

When a patient's case is complex, rare or the person making the diagnosis is simply inexperienced, an expert system can help come up with likely diagnoses based on patient data.

- **Therapy critiquing and planning**

Systems can either look for inconsistencies, errors and omissions in an existing treatment plan, or can be used to formulate a treatment based upon a patient's specific condition and accepted treatment guidelines.

- **Generating alerts and reminders**

In so-called real-time situations, an expert system attached to a monitor can warn of changes in a patient's condition. In less acute circumstances, it might scan laboratory test results or drug orders and send reminders or warnings through an e-mail system.

- **Agents for information retrieval**

Software 'agents' can be sent to search for and retrieve information, for example on the Internet, that is considered relevant to a particular problem. The agent contains knowledge about its user's preferences and needs, and may also need to have medical knowledge to be able to assess the importance and utility of what it finds.

- **Image recognition and interpretation**

Many medical images can now be automatically interpreted, from simple X-rays through to more complex images like angiograms, CT and MRI scans. This is of value in mass-screenings, for example, when the system can flag potentially abnormal images for detailed human attention.

Although, some of us had a question in mind whether the AI systems should come in clinical use or not. Now, today, there is good evidence that expert systems are working well (table 3.3 in chapter 3) as routine clinical use. Efforts are needed, however, to increase the number of such systems.

1.3. Usage and benefits

Before the development of an expert system starts, the issues related to its usage and benefits should be thought for its successful use. 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.

1.3.1. Levels of usage of a technical artifact

Gillies [14,15] 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 [16] 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 dialing. 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. **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.

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 [17] 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 [18] 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 are examples of 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 is not the role : writing a program is a task.

It is a fact that an automated knowledge-based consultation system should be useful for improved health care. It might not be feasible to appoint one paediatrician for each rural health centre 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 [19]. 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. Currently, there are good evidences that doctors and bio-medical researchers are actively participating with computer professionals in such projects.

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.

1.3.3. **Benefits**

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 [20] :

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 [21] is 'critical items are highlighted'. Task benefits are those which arise from using the expert system to support a task. Examples in DTI [21] 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 [21] is seen to arise from the two task benefits above.

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.1.6.

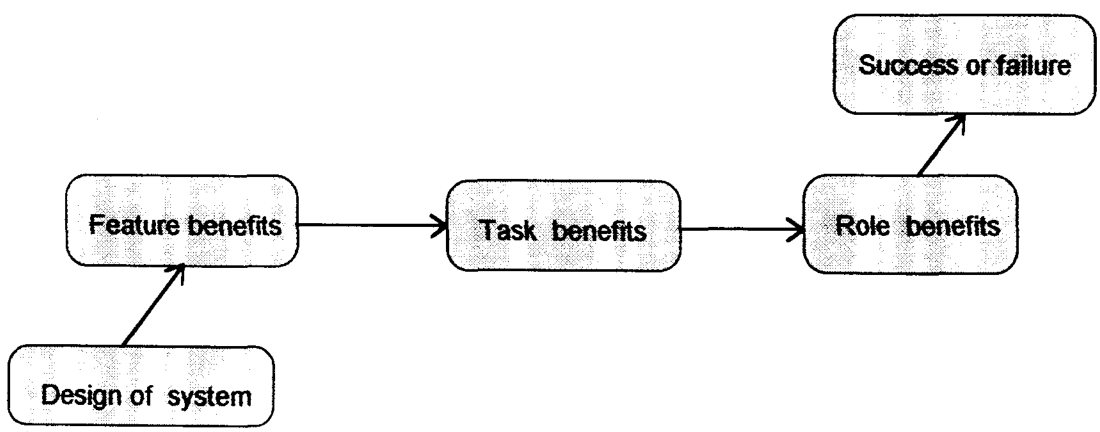

Fig.1.6 Three levels of benefit

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.

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.1.7.

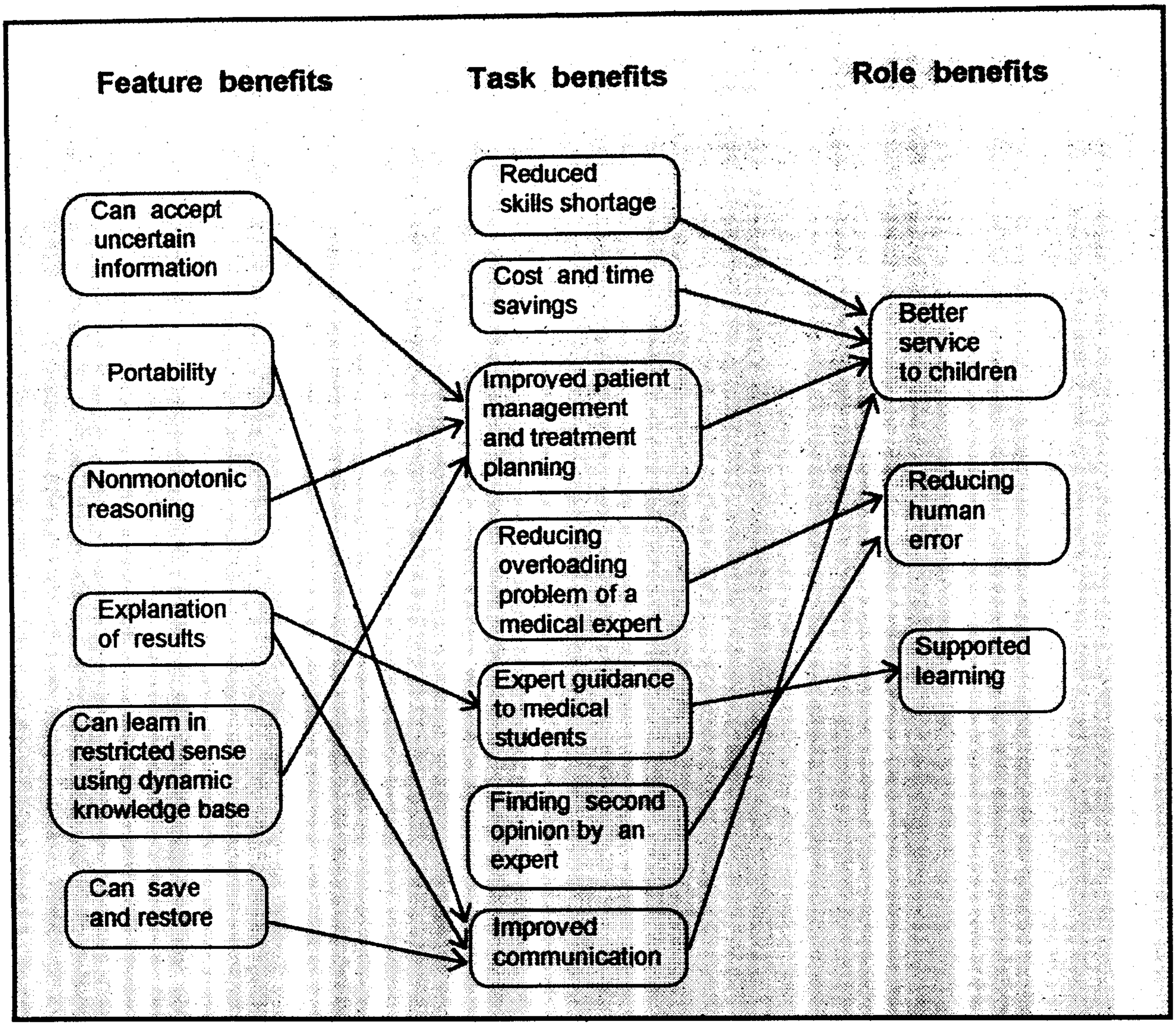

Fig.1.7. The levels of expected benefits in use of our proposed system

From the above fig. 1.7 it is seen 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. Moreover, though there is some causality of the links, while others are merely enabling. Further, there are other factors which influence the operation of each link, such as working practices, organizational norms and attitudes of users or others around them.

1.4. **Aim of the work**

The aim of the present work is to develop a knowledge-based consultation system for paediatric health care management. This we intend to do in steps. We initially have tried to explore the status of the domain which helped us in understanding the needs of the domain. To meet up the needs of the domain, atleast partially, an attempt has been made to develop an expert or knowledge based consultation system. Emphasis has been on different potential issues connected to an expert system development. Potential issues such as (i) knowledge acquisition and representation, (ii) uncertainty management, (iii) expert system tool selection, (iv) user interface, (v) performance evaluation and (vi) usage and benefits should be mentioned here.

The process of building an expert system is inherently experimental [22]. 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. Moreover, expert system development is the first and foremost software engineering [23] and therefore, there has been an attempt in the study to consider some software engineering issues during the development (e. g. phase refinement vs. prototyping).

1.5. **Summary of the work**

The scheme of presentation is as follows :

A. Chapter 2 of this thesis contains a brief survey on different aspects such as low birth weight, mortality and morbidity of the paediatric domain. There has been an attempt to include global as well as Indian scenario.

B. Chapter 3 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.

C. In chapter 4, we have presented two issues (i) knowledge acquisition and (ii) knowledge representation. Under the first issue, levels of knowledge and knowledge categories have been discussed. Next, we have explored different sources of knowledge acquisition - their merits and demerits. Here we have also pointed out the prime sources of knowledge acquisition used in the current research. Under the second issue, 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.

D. Chapter 5 contains the results of our sonographic studies on foetal growth performance of North Bengal districts of India. As knowledge acquisition source, this study was conducted. A comparison has also been made among the results of this study, one other Indian study and the results of different Western studies.

E. Chapter 6 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.

F. Chapter 7 deals with the issue of uncertainty management. 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.

G. Chapter 8 presents the issue of prototyping development; a software engineering issue. Phase refinement vs. prototyping has been presented. Lastly, our first prototype system is presented.

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. Here we have presented (i) prototype 2.0 based on some linguistic articulations and (ii) a fuzzy knowledge-based neonatal resuscitation management (prototype 3.0) with performance evaluation.

I. Chapter 10 presents an integrated prototype system (KID) for the domain (prototype 4.0). Performance evaluation of the system has been presented. Object-Oriented analysis, design and implementation have been incorporated. The graphical user interface (GUI) issue has also been discussed.

J. Chapter 11 has been devoted to a case study on neonatal resuscitation management incorporating a comparison of case based reasoning with rule-based reasoning (prototype 5.0). Performance evaluation has also been presented.

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