CHAPTER 1

Introduction

1.1. Introduction

The modern history of the computer has significantly elaborates that there is a process to develop an artificial electronic thinking mechanism which may take decision as when required, if the proper information is supplied. In the search of modern technology incorporating medical science and artificial intelligence, the doctors, scientists and researchers were mostly fascinated by the potential of such a technology. Even they started utilizing this technology in medical decision making. The processes of developing such a technology have been a subject of active research, which would be able to store and process huge medical information. More over it would be able to assist doctors, clinicians in various tasks like diagnosing, managing the disease, giving expert decisions. This actually motivates the scientists and researchers developing a discipline named Artificial Intelligence in medicine (AIM).

Consider a child having various symptoms of disease when comes for the treatment in the medical or any health home. They may likely to be seen by the junior doctor relatively having less clinical knowledge. Whereas the clinical knowledge and wisdom are concentrated among senior doctors, removal of several diagnosing steps may be useful for the patient. This may be one of the causes of medical decision making error. The impact of this kind may play significant role increasing mortality, morbidity and economic loss.

Now a day, clinicians are struggling with information overload. It is estimated that we use nearly 2 million pieces of information in our decision making and that biomedical knowledge is doubling every 20 years [1]. Moreover proper and adequate information may not be available all the time. Even the scarcity of domain experts also matters while diagnosing the disease and proper management of the patient.

Health, nutrition and education are the most significant attributes for the development of human resources. The overall progress of any region depends upon these criteria. Unfortunately, the scenario of the studied region covered under the thesis has been found uneven. This might be due to underfunding of heath sector, poor performance by the staff engaged in the health care system, unavailability of the domain expert, improper distribution of facilities in rural areas, poor socio economic condition, and behavioral changes in climates along with covering large population.

The majority of the neonatal deaths may be managed with cost-effective solutions like decision support system (DSS) in this domain. Proper nutrition and hygiene may the
important criteria in several cases. For this we need not require highly trained person or sophisticated equipments. Rather any system which has the capability to diagnose the proper disease may be a useful hand of the domain specialists.

In this study, an alarming result regarding the neonatal mortality rate has been found; the details of which are provided in chapter 3. This motivated us towards thinking of such a DSS providing support to decrease mortality rate to some extent using various artificial intelligence (AI) techniques. Modeling techniques and domain knowledge have been used by researchers occasionally for utilizing known information in complex problems. By the use of such modeling techniques in different related practical fields, the system may be highly beneficial and may improve the information retrieval and proper diagnosing performance. This work may bridge the gaps between medical professionals and the patients.

Most of the researchers and scientists are familiar with the statistical approach to data analysis. There have been attempts to discover humanly understandable concepts. Given a particular hypothesis, statistical tests are applied to data to see if any relationships can be found between different parameters. We look at raw data and then attempt to establish relationships between hypotheses within the data; whereas learning systems are able to produce complex characterizations of those relationships. Disease diagnosis for neonate is a specific application domain of AIM. Various expert systems have been developed for different diagnosis. Since only a limited number of such decision support systems have been developed for neonates, it is suggested that each individual can be better served by a decision support system customized to their particular interest.

This motivated us to initiate a study on neonatal diseases of North Eastern parts of India. The result of this study motivates us to develop a DSS for the domain treatment planning.
1.2. Decision Support System in Medical Informatics

1.2.1. Needs

During the research work, we found several reasons for which medical decision support system or the expert system can be applied. The reasoning area may be of the following:

❖ Workable and Assisting in Diagnostic Process

Decision support system may be helpful if it found workable and capability of assisting the diagnostic process in case of severe and critical case.

❖ Assisting Information Retrieval Process

This is really useful in the process of medical information retrieval from huge data base of domain related problem. To search any particular disease related problem based on specific criteria this may be immense help for the domain experts in medical informatics.

❖ Watchful and Reminding for use of Medicine

The system may be requiring sophisticated features for the patients, like in the case of medical test results, if that exceeds from normal range then it may generate signals and reminding the patient as well as doctors. So the system is watchful in nature.

❖ Assisting Diagnosing, Planning and Management

To get the ultimate result of diagnosis of the disease and thereby curing the patient, a proper planning and management is needed badly. It may be useful on this platform also.

❖ Assisting on Interpreting the Medical Image

Various forms of medical images like Digital X-Rays, MRI, CT Scan etc. are using different image standards. In this cases interpretation is very much required for the understanding of the proper information related to specific disease. Thus it is also useful in this field.

A Decision Support System (DSS) is actually assists decision making processes based on the available knowledge base of alternatives. DSS supports diagnosis and its probable actions. Even a medical decision support system helps to make a diagnosis of diseases and selects an appropriate treatment plan for a sick neonate patient. In some situation, DSS allows for complete automated process of decision making, and provides the mechanism for operational diagnostic intelligence. As we automate more
of our decision making process, it increases the speed and consistency in predicting
the diseases. This has been a direct impact on productivity, accurateness and time.
Knowledge base decision support system helps to filter out inaccurate experiential
results and biases around personal judgments. This is particularly important in medical
decisions, where a wrong decision has life impacting consequences, particularly for
the new born babies. Doctors, medical practitioners and domain related personnel are
suffering from high stress levels around decision making. When the concern cases are
complex and the outcome of the decision has significant consequences, DSS proves
itself to be an important expert hand. In a decision making system, expert involvement
is a must. Experts are engaged in their intuitive decision making rather than structured
approaches.

Decision support system may improve quality of neonatal care by increasing
clinicians’ available time for direct patient care. It also increases applications of
clinical pathways and guidelines. DSS facilitates the use of up-to-date clinical
evidence, improved clinical documentation and thereby expects patient satisfaction. It
also improves efficiency in health care delivery by reducing costs through faster result
processing, reductions in test duplication, decreased adverse events, and changed
patterns of drug prescribing favouring cheaper but equally effective brand.

1.2.2. Some of the Useful Help of DSS

- It can decrease variation in the quality of care.
- Automatic provision for expert advice, expertise and recommendations sourced
  from up-to-date, knowledge of best practices.
- It can support medical education and training.
- It can be a helpful tool to overcome problems of inefficient coding of data.
- This may be cost-effective except initial capital and update and maintenance
costs.
- It may provide immediate feedback to patients.
- If integrated with a service, which can help in history taking, diagnosis, treatment
  and encourage more efficient data gathering.
- It also provides an audit trail and support research.
- DSS maintains and improve consistency of care.
- Clinical information can be supplied anytime, anywhere it is needed applying
  DSS techniques.

In view of the same, it is recommended that, DSS is a not a decision making system,
rather it’s a decision support system.
1.3. Objectives of Research Study

1.3.1. Objectives

The main objective of our research is to explore conditions under which such a decision support system for neonatal disease diagnosis is feasible, and implement a concept prototype. This research work elaborates that, how an interactive decision support system having capabilities of machine programming with some specific rules enables a medical consultant on finding neonatal abnormalities. For a specific case, consultant works by prompting a doctor for a series of calls about different neonatal blood samples. On every occasion where anomalies are found, the system proceeds to create a chain of data-dependent questions to the user or doctor. For the improvement of diagnostic process, DSS would be beneficial tool for diagnoses of probable illnesses of a neonate and recommends courses of management, also guides for a proper treatment planning.

Intelligent systems that combine user profiling, data mining, and artificial intelligence techniques may be developed to provide many of the services that have traditionally been offered by the domain experts. This is the area of focus where our decision support system(DSS) is different from any others. We have used advanced data-mining (DM) techniques, soft computing (SC) techniques; rough set (RC) based applications, artificial neural networks (ANN), few hybridization techniques and used them to develop knowledgebase decision support system. This would be a perfect diagnosing assistant tool for guiding the domain experts and researchers in their diagnosis part and thereby taking proper neonatal care and management of the neonates. The system will learn about each case history and then be able to recommend items or suggest alternative terms of predicting the disease.

In a point of thinking, it is a matter of concern how the decision is being applied to represent the application domain. In our case, it is neonatal disease diagnosis. It also makes the knowledgebase use for both in theoretical and the practical level. Obviously, an unknown representation of the domain knowledge within the diagnosis task is not viable. Moreover, an unambiguous domain representation also provides the generosity of the diagnosis problem-solving method and facilitates the maintenance and reuse of knowledge as when needed. In the field of medical informatics, Artificial Intelligence (AI) provides a wide range of option to tackle this problem. But the selection of the particular approach implies the novel use of this knowledge representation formalization. In high complex conceptual like neonatal disease diagnosis, any chance of ignorance of knowledge causes serious impact on the neonatal health. Thus development of knowledgebase decision support system would be the primary objective of this research which would be beneficial to the experts and the society as well.
1.3.2. **Area of the Study**

The Study area where we have mainly worked for is on the North Eastern parts of India. This area actually refers to the North Bengal consisting: Darjeeling, Jalpaiguri, Tarai and Dooars region, Coach Behar. Besides, it includes Seven Sister states and Sikkim also. This area is ethnically different from the other parts of India. The said area has got strong ethnic and cultural ties with East Asia and Southeast Asia. The region has several groups of scheduled caste, tribes and other sub-tribal communities. It is predominantly rural with over 84% of the population living in the countryside. According to 2001 census, the total literacy rate of the population in the region is 68.5%. Female literacy rate is 61.5%, which is higher than the country's average literacy rate of 64.8% and 53.7% respectively.

This area is famous for TTT (Tea, Tourism & Table Tennis) culture, handicrafts, and wooden crafts. The area is full of unique scenic beauty. But there are dark sides as well. This area is suffering from unemployment, infrastructural problems and mostly of illiteracy. Rapid increase of population is one of the important indicators of the dark sides. This leads to various problems in the general people over the region. The health care system is not sufficient enough to provide all the necessary medication properly. Mostly, in village areas, there has been acute problem of neonatal prevalent diseases. We have concentrated mostly on the North Bengal Tarai and Dooars region for knowledge accusation process, which is discussed in chapter 3 vividly.

In this study, it is seen that North Bengal Medical College & Hospital is having tremendous pressure on providing medical health care facilities. This is because of overcrowding situating. People are coming from surrounding areas even from the neighbor countries like Bangladesh, Nepal and Bhutan for the treatment. Particularly Neonatal Intensive Care Unit (NICU) is seriously facing lack of services, neonatologist or the expert and proper infrastructure. Any attempt towards developing decision support system for the neonatal disease diagnosis would defiantly helpful in this region. Though the study has conducted on the said area, still the system might be treated as useful assisting tool for every domain specific users in global respect.

1.3.3. **Viability of Decision Support Systems**

The popularity of inference and knowledge representation schemes of modern decision support systems make them well appropriate to the development of disease diagnosis systems. Events related to disease, historical profile and sign symptoms directly integrated into knowledgebase and reasoning procedure. Disease diagnosis conditions can be performed concurrently with other reasoning jobs. With the capability of monitoring and evaluating the performances and actions, DSS provides extraordinary supports to the domain experts.
This system for neonatal prevalent disease diagnosis and treatment plan may have been successfully deployed in a number of demanding medical environments where neonatal intensive care is taken care of. Though, the system has generally dealt with monitoring neonatal disease diagnosis, still prediction of prevalent diseases and control management would be performed by the successful use of system.

Viability of the Knowledge-based DSS for neonatal disease diagnosis presented in this study is the evidence for architectural background generation and construction of decision support systems which is able to diagnose and produce the management of neonatal disease. It also describes the way in which this architecture was employed in the adaptation of the existing decision support system to meet the disease diagnosis requirements of neonatal domain. Finally, it analyzes the performance of the system in various platforms of artificial intelligence, data mining, soft computing, rough set computing and artificial neural networks. In viewing all the analytical performance the system measures its significant viability in the field of successful design of decision support system for the neonatal prevalent disease diagnosis and treatment planning.

This work is an attempt to propose a suitable approach to deal with the diagnosis problem and management of the disease in towering complex conceptual domains of prevalent neonatal disease. Initially our research hypothesis was to tackle all the troubles considering several approaches, scopes and their combination which would improve the efficiency of disease diagnose. Later on, our research is concentrated on two complementary approaches; firstly, uses a general point of view of knowledge description about the neonatal problems, and secondly, utilize the particular knowledge to obtain optimal solution and giving an accurate decision.

To solve the problems of a neonate, the basic knowledge regarding neonatal disease pattern have been considered. This proposal describes a theoretical model to represent the evolution of abnormal behaviours like diseases patterns, evolution of diseases and complexity of the said disease. This diagnostic process uses this knowledge to obtain explanations by the use of the disease patterns. This being a deductive approach as we obtain a solution for an actual problem using the general knowledge of neonatal prevalent diseases and their treatment plans. This has been reflected by the theoretical model in this work.

In various research stages, we have utilized the domain knowledge by implementing various theoretical models. The data have been analyzed, pre-processed, classify and then implement in the proposed model. The knowledge needed to solve a problem is based on previous solved problems. As an example, senior neonatologists usually make decisions based on their experience with previous patients. If any automated system assist the experts to diagnose the correct disease, then many problem may solved. Combining various approaches, two advantages could be recognized. Firstly, using various approaches we can represent a wider range of knowledge with prevalent
disease specific attributes, and secondly, the diagnostic process would use the advantage of various approaches to obtain an optimal solution towards developing knowledge based decision support system for treatment planning.

The experiments were based on the programs generating data which describe the behavior of the simulated models. Hypothesis about the behavior of the models were tested by statistical analysis with collected data. The program were implemented and after their critical analysis, more complex yet productive model were designed as well as developed using the resulting knowledge then tested the accuracy of predicting the diseases.

1.4. Overview of the Neonates and Neonatal Health Care

1.4.1. Overview

“Children are the future of the nation”. This famous quote is often used by many people all over the world. This may sounds good and seems to be right; but the reality remains there in dark side, that there are a plenty number of sick, filthy, hungry, beggarly kids all around us without having any hope of a secured future. Many children have been deprived of basic needs like food, proper shelter and sanitation, basic education, basic training and access to health care facilities. But every child has the right to protection, basic education, and proper healthcare, a healthy environment and good livelihood opportunities. This is because; in future they may be of nation builder. There is absolutely no doubt that health is wealth. A wealthy person having ill health cannot enjoy life. On the other hand, a poor man with good health can enjoy his life. Therefore, it is better to have good health. Every nation should provide proper health services to her every citizen. Good health status of every individual is equally important. It also important to looks after the children’s health status carefully by the parents or guardians. Particularly new born babies should be given ultimate care to maintain of his/her the future growth.

Health and education both are the fundamental rights of Indian citizen under the Constitution of India. Health, education, water and sanitation are not commercial services. Hence, the responsibility to ensure that each citizen receives good education and health care is a must. The most efficient of public health systems cannot achieve the best possible results unless they are supported by the welfare organizations having food availability and nutritional status, drinking water supply, housing, transport, education, employment and gender equality. In third world countries these are the most critical inputs without which health systems play a very minor role in preventing diseases. There has been an increased focus on issues that affect children and on improving their health.
Neonates are vital to the nation’s present and its future. All neonates needs and deserve a healthy start and has to be properly nourished before birth, in infancy, and during their growing years to receive basic health care both prenatally and during the crucial early years after birth. A proper scientific and public health advancement steps has been proving reduced mortality and morbidity rate of the children in recent days.

1.4.2. Neonates

New born period encompasses the first four weeks of extra uterine life [2]. A neonate is a baby who is 4 weeks of old or younger. A neonate is also called a newborn. The neonatal period is the first 4 weeks of a child's life. This period represents a time when changes occur rapidly, and many critical events can takes place. Newborn or neonate actually comes from Latin word, ‘neonatus’, which refers to an infant in the first 28 days after birth [3]. During the first 28 days, most present from congenital birth defects are discovered.

The total pediatric age group is subdivided as:

i. Fetal : Conception – Birth
ii. Neonates : 0 – 4 weeks
iii. Infants : 4 weeks – 1 year
iv. Toddler : 1 year – 3 years
v. Pre-School : 3 years – 5 years
vi. School Going : 5 years – 10 years and
vii. Adolescence : 10 years – 19 years.

First week of life is, less than 7 is or greater than 168 hours is known as early neonatal period. Late neonatal period extends from 7th to less than 28th day.

It should be pointed out that the disease patterns, drug selections, diets and common rearing technologies are different for the different pediatric age groups.

1.4.2.1. Few Terms Related to Neonate [2]

- Live Born

A live born neonate is a product of conception, irrespective of weight or gestational age after separation from mother. It shows any evidence of life such as breathing, heartbeat, pulsation of umbilical cord or definite movement of the voluntary muscle.
Still Birth

A fetal death is a product of conception that, after separation from the mother, does not show any evidence of life. This is at a gestational age of 20 weeks of more or weighing weighing not more than 500g is designated as still birth.

Term Baby

Any neonate born between 37 and < 42 weeks of pregnancy irrespective of the birth weight.

Pre-term Baby

Any neonate born before 37 weeks (<259 days) of pregnancy irrespective of the birth weight.

Post-term Baby

A neonate born at a gestation age of 42 weeks or more (294 days or more) irrespective of the birth weight.

Low Birth Weight (LBW) Baby

Any neonate weighing less than 2500g at birth irrespective of the gestational age is the LBW neonate.

Very Low Birth Weight (VLBW) Baby

Any neonate weighing less than 1500g at birth irrespective of the gestational age is the VLBW neonate.

Extremely Low Birth Weight (ELBW) Baby

Any neonate weighing less than 1000g at birth irrespective of the gestational age is the ELBW neonate.

Neonates not only constitute a large population group, but also are vulnerable or special risk group. The risk is related with growth, development, disease pattern and survival. From the commonly accepted indices, it is evident that mortality rates in this age group are higher than adult population especially in developing countries. Thus by improving the health status of neonates, we contribute to the health of the general population. These considerations have led to the formulation of special health service for children all over the world.
1.4.3. **Common Conditions in Newborns** [13]

Some physical conditions are especially common during the first couple of weeks after birth. They are as follows:

- **Abdominal Distension**

  Most babies’ bellies normally stick out, especially after a large feeding. Between feedings, however, they should feel quite soft. Most likely the problem is due to gas or constipation, but it also could signal a more serious intestinal problem.

- **Birth Injuries**

  It is possible for babies to be injured during birth, especially if labor is particularly long or difficult, or when babies are very large. While newborns recover quickly from some of these injuries, others persist longer term. Quite often the injury is a broken collarbone, which will heal quickly if the arm on that side is kept relatively motionless. Incidentally, if after a few weeks a small lump may form at the site of the fracture, this is a positive sign that new bone is forming to mend the injury.

  Muscle weakness is another common birth injury, caused during labor by pressure or stretching of the nerves attached to the muscles. These muscles, usually weakened on one side of the face or one shoulder or arm, generally return to normal after several weeks. At this time one should ask pediatrician to show how to nurse and hold the baby to promote healing.

- **Blue Baby**

  Babies may have mildly blue hands and feet, but this may not be a cause for concern. If their hands and feet turn a bit blue from cold, they should return to pink as soon as they are warm. Occasionally, the face, tongue, and lips may turn a little blue when the newborn is crying hard, but once he becomes calm, his color in these parts of the body should quickly return to normal. However, persistently blue skin coloring, especially with breathing difficulties and feeding difficulties, is a sign that the heart or lungs are not operating properly, and the baby is not getting enough oxygen in the blood. Immediate medical attention is essential.
Coughing

If the baby drinks very fast or tries to drink water for the first time, he may cough and sputter a bit; but this type of coughing should stop as soon as he adjusts to a familiar feeding routine. This may also be related to how strong or fast a breastfeeding mom’s milk comes down. If he coughs persistently or routinely gags during feedings, one should consult the pediatrician. These symptoms could indicate an underlying problem in the lungs or digestive tract.

Excessive Crying

All newborns cry, often for no apparent reason. If anyone made sure that the baby is fed, burped, warm, and dressed in a clean diaper, the best tactic is probably to hold him and talk or sing to him until he stops. One cannot “spoil” a baby this age by giving him too much attention. If this doesn’t work, wrap him snugly in a blanket.

One will become accustomed to baby’s normal pattern of crying. If it ever sounds peculiar—for example, like shrieks of pain—or if it persists for an unusual length of time, it could mean a medical problem. Then one should call the pediatrician and ask for advice.

Forceps Marks

When forceps are used to help during a delivery, they can leave red marks or even superficial scrapes on a newborn’s face and head where the metal pressed against the skin. These generally disappear within a few days. Sometimes a firm, flat lump develops in one of these areas because of minor damage to the tissue under the skin, but this, too, usually will go away within two months.

Jaundice

Many normal, healthy newborns have a yellowish tinge to their skin, which is known as jaundice. It is caused by a buildup of a chemical called bilirubin in the child’s blood. This occurs most often when the immature liver has not yet begun to efficiently do its job of removing bilirubin from the bloodstream (bilirubin is formed from the body’s normal breakdown of red blood cells). While babies often have a mild case of jaundice, which is harmless, it can become a serious condition when bilirubin reaches what the pediatrician considers to be a very high level. Although jaundice is quite treatable, if the bilirubin level is very high and is not treated effectively, it can even lead to nervous system or
brain damage in some cases, which is why the condition must be checked for and appropriately treated. Jaundice tends to be more common in newborns who are breastfeeding, most often in those who are not nursing well; breastfeeding mothers should nurse at least eight to twelve times per day, which will help produce enough milk and help keep bilirubin levels low.

Jaundice appears first on the face, then on the chest and abdomen, and finally on the arms and legs in some instances. The whites of the eyes may also be yellow. The pediatrician will examine the baby for jaundice, and if she suspects that it may be present—based not only on the amount of yellow in the skin, but also on the baby’s age and other factors—she may order a skin or blood test to definitively diagnose the condition. If jaundice develops before the baby is twenty-four hours old, a bilirubin test is always needed to make an accurate diagnosis. At three to five days old, newborns should be checked by a doctor or nurse, since this is the time when the bilirubin level is highest; for that reason, if an infant is discharged before he is seventy-two hours old, he should be seen by the pediatrician within two days of that discharge. Some newborns need to be seen even sooner, including:

- Those with a high bilirubin level before leaving the hospital
- Those born early (more than two weeks before the due date)
- Those whose jaundice is present in the first twenty-four hours after birth
- Those who are not breastfeeding well
- Those with considerable bruising and bleeding under the scalp, associated with labor and delivery
- Those who have a parent or sibling who had high bilirubin levels and underwent treatment for it.

When the doctor determines that jaundice is present and needs to be treated, the bilirubin level can be reduced by placing the infant under special lights when he is undressed, either in the hospital or at home. His/her eyes will be covered to protect them during the light therapy. This kind of treatment can prevent the harmful effects of jaundice. In infants who are breastfed, jaundice may last for more than two to three weeks; in those who are formula-fed, most cases of jaundice go away by two weeks of age.
Lethargy and Sleepiness

Every newborn spends most of his time sleeping. As long as he wakes up every few hours, eats well, seems content, and is alert part of the day, it's perfectly normal for him to sleep the rest of the time. But if rarely alert, does not wake up on his/her own for feedings, or seems too tired or uninterested to eat, one should consult your pediatrician. This lethargy, especially if it is a sudden change in his usual pattern, may be a symptom of a serious illness.

Respiratory Distress

It may take our baby a few hours after birth to form a normal pattern of breathing, but then he should have no further difficulties. If he/she seems to be breathing in an unusual manner, it is most often from blockage of the nasal passages. The uses of saline nasal drops, followed by the use of a bulb syringe, are what may be needed to fix the problem; both are available over the counter at all pharmacies.

However, if newborn shows any of the following warning signs, notify your pediatrician immediately:

- Fast breathing (more than sixty breaths in one minute), although keep in mind that babies normally breathe more rapidly than adults.
- Retractions (sucking in the muscles between the ribs with each breath, so that her ribs stick out)
- Flaring of his/her nose
- Grunting while breathing
- Persistent blue skin coloring

1.4.4. Neonatal Health Care

The statistics in developing countries shows that mostly children, adults and particularly neonates are vulnerable to malnutrition because of below standard dietary intakes, infectious and communicable diseases, deficiency in appropriate caring and unbalanced food distribution within the family. Three standard indices of physical growth that describe the nutritional status of children are:

- \textit{Height-for-age (stunting)}
- \textit{Weight-for-height (wasting)}
- \textit{Weight-for-age (underweight)}
Introduction and Objectives

As per the Third National Family Health Survey (NFHS-3, 2005-06) [4], almost half of children under five years of age (48%) are stunted and 43% are underweight. The proportion of children who are severely undernourished (more than three standard deviations below the median of the reference population) is also notable, 24% according to height-for-age and 16% according to weight-for-age. Wasting is also quite a serious problem in India, affecting 20% of children under five years of age.

Neonates are generally viewed as healthy when they are assessed by child standards, and there has been a great deal of progress in reducing neonatal death and diseases. But the country should not be unsighted by these facts. Several indicators of neonate’s health point to the need for further improvement. A recent improvement in neonates’ health needs to be sustained and further efforts are needed to optimize it. To accomplish this, the nation must have an improved understanding of the factors that affect health and effective strategies for measuring, accessing and using information on neonate’s health.

The greatest concern in the regionalized specialty care services and special dependence of modern neonatology. Because serious illness is far less prevalent in children than in adults, pediatrics must concentrate patients into networks of regionalized centers with special expertise and resources. Adult care can tolerate far more decentralized services. As a result many cost containment strategies are being directed towards financial contracting networks that create strong disincentives for the use of specialty care facilities. There should be advancement in highly regionalized neonatal care systems may prove increasingly difficult against a rising current of de-regionalization based on adult-focused financial contracting.

The task for the neonatology community, as it is for all those concerned for the health and well-being of children is to create the technical guidance and political voice to ensure that the special requirements of young women, newborns, and children are represented adequately in the often fractious deliberations over the future of health care.

In recent years, there has been an improved focus on issues that affect neonates and on improving their health status. Neonates are forming the largest proportion of immediate workload in primary healthcare. Neonates are vital to the nation’s present and its future. All children need and deserve a healthy start - to be properly nourished before birth, in infancy, and during their growing years to receive basic health care both prenatally and during the crucial early years after birth. Scientific and public health advances have improved access to health care and hence, reduced child mortality and morbidity from infectious diseases, accidental causes, even from prevalent diseases. To promote health services today we require considerations of the overall status of neonates, only identification and treatment of specific diseases or deformities is not sufficient to take proper decision.
1.5. Examination Procedure of a Sick Neonate

A neonate must be examined as soon as after delivery, and ideally before discharge from hospital or next day for home births or rapid discharges. The initial examination is usually conducted by midwifery staff in cases of uncomplicated delivery, or by the on-call pediatrician for complicated births.

Figure 1.1. Examination Procedure of a Sick Neonate.

Each and every newborn baby is carefully checked at birth for signs of problems or complications. A complete physical assessment will be performed that includes every body system. Throughout the staying period of hospital, physicians, nurses, and other healthcare providers continually assess a baby for changes in health and for signs of problems or illness.

1.5.1. **Neonatal Examination Procedure**

1.5.1.1. **NEST: Neonatal Examination and Screening Trial** [5]

It is seen that few hospitals and tertiary centers have been maintain a policy of conducting two pediatric neonatal examinations. Firstly, just shortly after birth to detect any abnormalities that require urgent action, and secondly, before the discharge of the neonate. A trial comparing one with two neonatal examinations found no evidence of a net health gain from the policy of double examination. There were no differences between the two groups with respect to use of community, outpatient, and inpatient resources, or in health care received. It concluded that a single examination policy would save resources both during the postnatal hospital stay, and through fewer outpatient consultations.

1.5.1.2. **Initial Post-Delivery Examination**

Neonates are undergone a brief screening examination. It includes checking the face, eyes, mouth, chest, abdomen, spine and limbs to exclude major abnormalities. Neonates may be well if, a strong cry and a widespread pink blush over the face and body are found. Some children may be born with indiscriminate genitalia. In that case it is important not to guess at the likely gender of the child, but advise that it is uncertain and that further tests will be needed. If you have sufficient clinical experience an orogastric tube should be passed when the neonate's mother has suffered polyhydramnios.

1.5.1.3. **The APGAR score**

The very first test given to any newborn is the APGAR scoring. This occurs in the delivery or birthing room right after your baby's birth. The test was designed to quickly evaluate a newborn's physical condition and to determine any immediate need for extra medical or emergency care.

The acronym for APGAR is:

\[
\text{A : Appearance, } \\
\text{P : Pulse,}
\]
The APGAR score gives a reproducible, quantitative, semi-objective assessment of neonatal condition that is useful for assessing a baby's progress or deterioration immediately after delivery [6]. It is important to document it for medical reasons. It is most useful following complicated births or where there are unanticipated problems with the baby after delivery. It should be checked at delivery and 2 and 5 minutes subsequently; these results should be documented in the maternal and neonatal notes.

### Table 1.1. APGAR Scoring

<table>
<thead>
<tr>
<th>APGAR Sign</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate (pulse)</td>
<td>Normal (above 100 beats per minute)</td>
<td>Below 100 beats per minute</td>
<td>Absent (no pulse)</td>
</tr>
<tr>
<td>Breathing (rate and effort)</td>
<td>Normal rate and effort, good cry</td>
<td>Slow or irregular breathing, weak cry</td>
<td>Absent (no breathing)</td>
</tr>
<tr>
<td>Grimace (responsiveness or &quot;reflex irritability&quot;)</td>
<td>Pulls away, sneezes, coughs, or cries with stimulation</td>
<td>Facial movement only (grimace) with stimulation</td>
<td>Absent (no response to stimulation)</td>
</tr>
<tr>
<td>Activity (muscle tone)</td>
<td>Active, spontaneous movement</td>
<td>Arms and legs flexed with little movement</td>
<td>No movement, &quot;floppy&quot; tone</td>
</tr>
<tr>
<td>Appearance (skin coloration)</td>
<td>Normal color all over (hands and feet are pink)</td>
<td>Normal color (but hands and feet are bluish)</td>
<td>Bluish-gray or pale all over</td>
</tr>
</tbody>
</table>

Five factors are used to evaluate the baby's condition and each factor is scored on a scale of 0 to 2, with 2 being the best score:

1. appearance (skin coloration)
2. pulse (heart rate)
3. grimace response (medically known as "reflex irritability")
4. activity and muscle tone
5. respiration (breathing rate and effort)

There is an excess of mortality and an increased risk of severe neurological morbidity in infants with total APGAR score <7 at 5 minutes [7].
1.5.1.4. Stepwise Routine for New Born Check-Up [8]

First wash hands thoroughly to reduce the risk of cross-infection. After that performs the followings:

❖ **Listen and Observe**

- **Assess overall appearance.** Note general tone, sleepiness and also observe general condition, proportions and maturity.
- **Look carefully** for evidence of jaundice (preferably in bright, natural light). Are there any birthmarks, rashes or other skin abnormalities?
- **Listen** to the baby's cry and note its sound.
- **Weigh** the baby and plot this reading on its growth chart.

❖ **Perform a systematic 'head-to-toes' examination**

This should be done carefully and in good light to detect abnormalities:

- **Head:**
  - Shape, presence of fontanel and whether normal, sunken or bulging.
  - Measure and record head circumference on growth chart.
  - Assess facial appearance and eye position.
  - Look for any asymmetry or abnormality of facial form.

- **Eyes:**
  - Normal shape and appearance?
  - Check for presence of red reflex.
  - Look for obvious cataracts or signs of ophthalmic infection.

- **Ears:**
  - Shape and size.
  - Are they set at the normal level or 'low set'?
  - Check patency of external auditory meatus.

- **Mouth:**
  - Colour of mucous membrane, observe the palate.
  - Check suckling reflex by inserting a clean little finger gently inside baby's mouth.

- **Arms and hands:**
  - Are they of normal shape and moving normally?
• Look for evidence of traction birth injury by checking neck, shoulders and clavicles.
• Count fingers and observe their shape – is there any evidence of incurving of fingers?
• Check palmar creases – are they multiple or single? A single palmar crease may be normal, but can be a sign of Down's syndrome.

- **Peripheral pulses:**
  • Check brachial, radial and femoral pulses for rate, rhythm and volume.
  • A hyperdynamic pulse may suggest persistent ductus arteriosus.
  • A weak pulse may occur with a congenital cardiac anomaly (impairing cardiac output and in conjunction with other signs from the examination).
  • Check for radio-femoral delay (aortic coarctation).

- **Heart:**
  • Check cardiac position by palpation and feel for any thrill or heave.
  • Listen to the heart sounds carefully and for any added sounds or murmurs.
  • Suspected abnormalities require further examination (and often more expert opinion and investigation).

- **Lungs:**
  • Watch respiratory pattern, rate and depth for a few seconds.
  • Look for any evidence of intercostals recession.
  • Auscultate lung fields for added sounds.

- **Abdomen:**
  • Look at abdominal girth and shape.
  • Carefully check the umbilical stump for infection or surrounding hernia.
  • Palpate gently for organs, masses or hernia.
  • It is common to be able to feel the liver and/or spleen in healthy newborns.
  • Check the external genitalia carefully (see Ambiguous Genitalia).
  • Palpate for testicles in boys.
  • Inspect the anus (has meconium been passed?).
• **Back:**
  - Look carefully at skin over back and at spinal curvature/symmetry.
  - Is there any evidence of spina-pilonidal sinus hidden by flesh creases or dimples?
  - Palpate the spine gently.

• **Hips:**
  - Specifically test for congenital dislocation of the hip using combination of Barlow and Ortolani manoeuvres.

• **Legs:**
  - Watch movements at each joint.
  - Count toes and check shape.

• **CNS:**
  - Observe tone, behaviour, movements and posture.
  - Elicit newborn reflexes only if there is cause for concern.

Further examination should be conducted as necessary according to any abnormalities that are detected, or suspicions of undetected illness in the baby.

- **Record findings**

Always document the findings of the examination in the postnatal care plan and personal child health record. A pro-forma for the examination, kept within the notes, can save time and act as a prompt to ensure that no element of the examination is missed.
1.6. Three Levels of Benefits

Three levels of benefits are proposed by Basden are as follows [9]:

a) Feature benefits;

b) Task benefits;

c) Role benefits.

a) Feature benefits:

The advantages which begin from technological features of functionality and user interface are termed as feature benefits. Ease of manipulation can arise, for instance, from graphical user interfaces. An example found in DTI [11] is “critical items are highlighted”.

b) Task Benefits:

The advantages which takes place from the use of any expert system to support a task is task benefits.

c) Role Benefits:

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 [11] is seen to arise from the two task benefits above.

After classifying the benefits into three sets, it is important to have the 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.

1.6.1. Usage of Decision Support System

As we have mentioned earlier also that, Decision Support System for neonatal disease diagnosis mainly focused on the point of care. Such a system may be of automated in nature. The pediatricians would interact with the system for diagnosis, analysis, and even management of the data provided to system [11]. Earlier, these types of system were basically used for making decision only. The user had to input the data to be processed and then waits for the outputs generated by the system only. But now the concept has changed. The new system actually forces the user to interact with the system with having user or domain expert’s knowledge and also with system knowledgebase to make a utmost analysis and proper diagnosis.

Clinical Decision System may categorize in two parts:
1.6.2 Knowledge-Based DSS

In knowledge-base DSS, there are mainly three parts: (i) Knowledge Base, (ii) Inference engine, and (iii) a way to communicate. The data there in the knowledge base are compiled mostly with rules and associations and that are in the form of IF-THEN-ELSE rules. The inference engine combines the rules from the knowledge base with the patient’s data and then communication method will allow the system to show the results to the user as well as have input into the system [11]. This has been performed in an environment which is termed as Expert System Cell. We have used this kind of system in our research work using neonatal data.

1.6.3. Non-Knowledge-Based DSS

This kind of decision support system uses a form of mostly machine learning and soft computing techniques, which is a field of Artificial Intelligence. This uses system to learn from the experience they have gathered earlier and finds suitable patterns in the data provided to them. Genetic algorithm and artificial neural network are the most common types of non-knowledge based decision support system. In our research we have used this paradigm efficiently to find the maximum accuracy of disease classification.

1.7. Benefit That We May Expect From Proposed System

For getting ultimate benefit of discussed neonatal domain, an automated knowledge-based decision support system would be beneficial. Rural health centre are lacking of neonatologists or pediatricians or domain experts to serve the medical facility, thus, the proposed system may be used by general people which is related to domain, particularly medical practitioners. This system would also assist the general physicians, working at sub-divisional/district hospitals or engaged in private practices. If there is an infrastructural problem of setting up huge machinery, this system might be useful as a mobile medical unit having one personal computer with required power supply. This system even helpful to medical students also, as if they are not having expert guide on real time, the proposed system might be act as assisting tool, using which they can get the proper decision or may get the second opinion to tally.

As the population increases every day, disease also increases on the same ratio. Thus creating overburden problems for the domain experts, neonatologists or pediatricians. This problem may also be reduced by the use of the proposed system.
Above all, we the general people need the best treatment for the diagnosed disease. Even we needs better patient management and treatment planning. Using this proposed system we certainly expect better patient management with ultimate accuracy. Moreover, it would be saving time, huge expenditure and to some extent mental harassment.

The proposed system does not require any knowledge of Artificial Intelligence (AI) or Decision Support System (DSS) terminology, not even advance training on computer is required to run this system. Any user having little domain knowledge and operational knowledge may handle this efficiently.

Finally, Different funding agencies of Govt. of India are really encourages research projects for the development of such decision support systems using Artificial Intelligence and Expert Systems technology under human resource development schemes[12]. In the growing age of ICT, every medical practitioner is now computer savvy. They are adopting such kinds of system as their assisting tool. Currently, there are good evidences that doctors and bio-medical researchers are actively participating with computer professionals in their projects. Moreover medical professionals are using equipments where the kinds of expert systems are embedded.

Thus taking consideration of growing information technological demands proposed system would be of great help not only for the domain experts but for the society too.

1.8. Summary of the Research Work

The chapter wise scheme of presentation is organized as follows:

i. Present Medical and Neonatal Domain and their Characteristics with Statistical Importance -- Chapter 2:

   In this chapter, brief discussions have done on the medical knowledge as well as neonatal domain knowledge and their characteristics. Various neonatal disease pattern and their causes has also been discussed. Neonatal mortality and morbidity status and various statistical importance with different related indicator of the said domain in global, thereafter, Indian perspective of has been included in this chapter.

ii. Study on the Status of New Born in Terai Region of West Bengal -- Chapter 3:

   This chapter has been devoted on the study of the status of New Born in Terai Region of West Bengal. A comprehensive study with different factor of
neonatal diseases along with prevalence factor finding has been summarized. We find various neonatal prevalent diseases and their causes. Data have collected, summarized and then analyzed for statistical analysis. Analyzed data are used in the subsequent study mentioned in the following chapters.

iii. A Decision Support System for Prevalent Disease Diagnose & Management for Neonates using ES-Technology -- Chapter 4:

This chapter begins with the representation formalisms which are conventionally used in Expert System. A detail neonatal problem in the study area has been given. A system flow diagram reflects how actually the expert system works in this case. How expert system as a tool or agent helps diagnosing the prevalent disease among the neonates has been discussed. Total information related to the information and knowledgebase development, inference processed is presented here. An outcome of the diagnosing procedure is described. We have explored different issues of knowledge accusation used in the current research. Also relative suitability of the problem discussed in this context in present domain.

iv. A Data Mining and Knowledge Unearthing Concept -- Chapter 5:

The need of knowledge and data mining, knowledge unearthing process in medical disease diagnosis, particularly for the neonatal disease data, has been discussed in this chapter. Several issues related to knowledge base development and data mining using clustering mechanism shows effective in this study, which have been presented here.

v. An Improved Data Mining Concept -- Chapter 6:

This chapter deals with the development of an improved data mining concepts for neonatal disease diagnosis in North Bengal Districts. Data mining through Decision Tree and C4.5 algorithm shows better results in this chapter. Implementation classifier like J48 has been utilized. Different classifiers characteristics like ROC, TP rate, FP Rate, F-measure, Recall has been analyzed with real life data. Finally finds the classifier accuracy depending on those characteristics. For evaluating model quality, there are different popular test metrics for classification models such as confusion matrix, prediction accuracy, receiver operating characteristics and lift have been discussed. Also the chapter presents a confusion matrix generated by the model.

vi. Diagnosis with Soft Computing -- Chapter 7:

In this chapter we present method of designing a hybrid decision support system in Soft Computing paradigm. This includes the application of rough set theory and C4.5 classification algorithm. Generation of rules based on the
rough set approach and classification through C4.5 algorithm has done on the data set. The methodology of different classification parameters including confidence factor, folding etc. also presented for the model.

vii. **Rough Set Based Model for Differential Diagnosis -- Chapter 8:**

We present an effective approach for managing uncertainties using Rough Set based model. How insignificant rules can sidetrack using reduct and core generation has been discussed in this chapter. ID3 Entropy and information gain has been discussed. There is comparison analysis among the different algorithm like Exhaustive, Genetic and Johnson for reduct and core generation using the data set is presented. A detailed comparison with Rough Set and ID3 has been provided.

viii. **Coupling with Data Mining and Rough Set Theory -- Chapter 9:**

The projected work in this chapter reports the results of a study where some coupling with data mining and rough set theory is proposed for differential neonatal disease diagnosis. Study ensures us that with the use of conventional analysis along with data mining and statistical studies in patient data can improve better disease diagnosing capacity with good accuracy rate. Even using data mining techniques data quality and standard of data, diagnosing plans and treatment procedures and decreases of treatment timings must be improved no doubt. This study in this chapter also suggests that, as this is differential diagnosis, the results might be accepted as first order inference. The next higher order performance is achieved with the results of laboratory tests.

ix. **Expert System Model Using Rule Based Reasoning System – Chapter 10:**

In this chapter we expressed how the expert system model can be useful for disease diagnosis. This might be helpful as any information that enables individuals to understand their health and make health-related decisions for their family and take care of the little child easily. We have discussed how rule have been generated using Level 5 Object, an AI Shell, and further validated the same using RSES, ROSETA, WEKA, rough set data mining tools. The chapter significantly elaborates that there is absolutely no contribution of three attributes ‘Excessive Jaundice’, ‘Sclerema’, and ‘GI Disorder’ in decision making. Overall clarification has been discussed here in this chapter. A comparative study shows that this model may give a useful and better tool for expert opinions and decision making.
x. **Artificial Neural Network (ANN) Model for Neonatal Disease Diagnosis – Chapter 11:**

This study represents the use of artificial neural networks in predicting neonatal disease diagnosis. How training in a Multi Layer Perceptron (MLP) with a Back Propagation (BP) learning algorithm for recognizing pattern for the diagnosing and prediction of neonatal diseases is vividly discussed. Comparative study of using different training algorithm of MLP, Quick Propagation, and Conjugate Gradient Descent has done for showing better prediction accuracy. There is a discussion on conventional computing method and Neural Network. Development of Neural Network Architecture, hidden layer selection, pre-processing, data set partitioning and training on the neonatal data set has been described in this chapter.

xi. **Neuro-Genetic Fusion Approach for Development of DSS – Chapter 12:**

In this chapter, a Neuro-Genetic Fusion approach has been proposed to find and select the best input features for diagnosis of neonatal disease. The fusion process has done with Neural Network with Genetic algorithm. Attributes are selected based on the use of Genetic Algorithm. Total description of genetic algorithm and how it worked in our study has been discussed. Selection for attribute subsets has done by the Attribute Subset Evaluator using Genetic Algorithm. Selected subset then pre-processed and analyzed for choosing best network architecture. We discussed about Batch Back Propagation training algorithm to train the network using various training algorithm parameters. Data set partitioning, pre-processing and training using different Neural Network using batch back propagation algorithm has been provided in this chapter. A comparative analysis of typical ANN with Neuro-Genetic Fusion has focused the better performance and accuracy of predicting the neonatal disease.

xii. **Intelligent Diagnostic System Development in Soft Computing Environment using Artificial Neural Network – Chapter 13:**

This chapter deals with development of computer aided intelligent diagnostic system. Description of computational intelligence and artificial intelligence is given with specific examples related to our research study. Quick propagation and conjugate gradient descent algorithm has been applied for training the data set because of huge network weight. Feature extraction and reduction is one of the important steps for pattern recognition for that implementation of Correlation-based Feature Reduction has been reflected on our specified area of study.
Accomplishment of the Objectives and Future Scope – Chapter 14:

This is the final chapter of our research work. It includes the how we accomplish our objectives that mentioned in the chapter I. Even our future extensions of study have been discussed. Here we mentioned how to accomplish the research objectives and reaching the goal after a numbers of research analyses. The chapter also illustrates about research objectives that sets the purpose and focus of our study with the fundamental questions that have already been addressed in different chapters in the thesis. We conclude our discussion after discussing the future scope of this research work.
References


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