Chapter 1

Introduction

1.1 Introduction To Healthcare Scenario In India

The United Nations Organization uses Human Development Index (HDI) to measure the level of human development in a nation. There are a number of parameters. Apart from economic wellbeing, that indicates the human development, healthcare is one of the key considerations of human progress. As far as India is concerned, in this connection, it not rated well. It is lagging behind its neighbors like Sri Lanka, China and Bangladesh on several key healthcare parameters. This is reported in the Economic Survey 2007-08. In order to understand the prevailing healthcare scene in India in comparison to the developed nations, the table 1 has been derived from the United Nations Development Programme website [1]. It indicates that India is performing poorly on every aspect in general, and very poor in case of controlling Infant Mortality Rate (IMR). For instance in India, the IMR under five years of age among the poorest is 141 out of 1000 live births. The main cause of this deplorable condition is lack of skilled health care personnel attending the births for the poor. It is estimated that only 16% deliveries are assisted by the skilled workers. Table 1 also depicts the shortage of the physicians. In India, 60 physicians attend 1 lakh patients whereas in the US, 256 physicians attend the same number of the patients. All these factors are responsible for poor HDI of India that is ranked 128.
**Table 1.1: Comparison of Human Development Indicators of various countries**

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<tbody>
<tr>
<td>Public expenditure on health (% of GDP)</td>
<td>6.8</td>
<td>8.2</td>
<td>6.9</td>
<td>7</td>
<td>2</td>
<td>0.9</td>
<td></td>
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<tr>
<td>Health expenditure per capita (PPP US$)</td>
<td>3,173</td>
<td>3,040</td>
<td>6,096</td>
<td>2,560</td>
<td>163</td>
<td>91</td>
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<tr>
<td>Children with diarrhoea receiving oral rehydration and continued feeding (% under age 5)</td>
<td>1998-2005</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>22</td>
</tr>
<tr>
<td>Physicians (per 100,000 people)</td>
<td>214</td>
<td>337</td>
<td>256</td>
<td>230</td>
<td>55</td>
<td>60</td>
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<tr>
<td>Births attended by skilled health personnel, poorest 20% (%)</td>
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<td></td>
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<td>16</td>
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<td>Infant mortality rate, poorest 20% (per 1,000 live births)</td>
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<td>97</td>
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<td>Infant mortality rate, richest 20% (per 1,000 live births)</td>
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<td>38</td>
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<tr>
<td>Under-five mortality rate, poorest 20% (per 1,000 live births)</td>
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<td></td>
<td>141</td>
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<tr>
<td>Under-five mortality rate, richest 20% (per 1,000 live births)</td>
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<td></td>
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<td>46</td>
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There is a need to understand why India is not performing well particularly in dealing with the childhood diseases. The Economic Survey of 2007-08 pointed out that there are numerous reasons contributing to the existing bad shape of our healthcare system. The main reasons are: inadequate funds, trained staff and health infrastructure which have led to the gaps in coverage and outreach services in rural areas; and the majority of the Indian population is living in these areas. According to the National Commission on Population (India), in 2002, approximately Rs. 643.1 million were needed for infrastructure and services of 1,774 more pediatricians were required. The Commission also observes that main contributors to high IMR in India are the states having a majority of population residing in the rural areas as shown in Table 1.2.

Table 1.2 IMR within Indian States (1999) per thousand

<table>
<thead>
<tr>
<th>STATES</th>
<th>Orissa</th>
<th>Madhya Pradesh</th>
<th>Uttar Pradesh</th>
<th>Rajasthan</th>
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</thead>
<tbody>
<tr>
<td>IMR</td>
<td>98</td>
<td>98</td>
<td>85</td>
<td>83</td>
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</table>

The social setup in these areas is also not conducive to changes. This is why it has been observed that medical facilities in India are not yielding good results even though government expenditure is increasing every year. There is an observation that India has relatively poor health outcomes because of poor policymaking and misdirecting efforts.

India is currently ranked 2nd in population worldwide with a total population of 1.087 million in 2004 [62] and is expected to surpass China in a few years and the majority is living in rural areas. In 2050, India’s total population is expected to be 1628 million with a birth rate per woman of 3.1 children. This will worsen the situation. Some of the problems with Indian health system are discussed below.
1.1.1 Limitations of Indian Health System

1. Poor Literacy Rate: In India, a very huge population is uneducated and illiterate. This poses a big problem in providing good health care since they are orthodox in thinking and are often reluctant to adapt to new techniques or technologies.

2. Low Socio Economic Status: Distribution of wealth in India is not uniform. Some are very rich while a major section of population; almost 26% is living below poverty line according to UNICEF. These people cannot afford medicines.

3. Lack of Qualified Doctors: The growth of population is not proportionate to the number of doctors graduating every year from medical colleges. This leads to the mushrooming of quacks and under-educated doctors.

4. Lack of Control of Government Agencies: The government agencies are not very effective in checking the quality of health care being provided. Private hospitals are charging hefty amounts from patients even without providing sufficient treatments. Even chemists, medical representatives and lab technicians are recommending medicines.

5. Poor Medical Facilities: The medical facilities in government hospitals are not adequate or poorly managed. They lack expert doctors, equipments and other resources. Moreover, management of these facilities lacks professionalism.

6. Political Interference: Due to political interference in the health care system, doctors and other staff members are not performing as is expected. Purchases of equipments and medicines are often not in accordance to the needs of the patient population.

7. Excessive Privatization: There is no check on privatization of hospitals and clinics. This leads to a situation where patients belonging to high-income group can afford treatments while the poor are deprived of basic medical facilities.

8. Lack of Facilities to tackle Potential Epidemics: Whenever epidemic outbreaks occur in India, the limitations of health system are revealed. This generally
happens in rural areas where the situation is quickly exacerbated due to poor facilities at these sites.

Before suggesting any solution to this grave problem, it is imperative to have an insight into the healthcare model that is adopted by Indian government.

### 1.2 Healthcare Model in India

A three-tier healthcare model is prevalent in India. Tier 1 is Primary Health Center (PHC) or a rural dispensary. The primary responsibility of providing treatment to young infants/children generally lies with the PHC only. The Health Care Practitioner (HCP) posted at this facility may refer the patient to Tier - 2 facilities. It is termed as Community Healthcare Center (CHC). A pediatrician is available there to cater to the patients referred by various PHCs. The pediatrician at this center may refer the patients with serious ailment to the Super Specialist Hospital, i.e. Tier -3. Such multi-specialty centers are usually research institutes, equipped with the world class physical infrastructures. The whole system is depicted in the Figure 1.1. The details of infrastructure and facilities at PHC and CHC are described below:

#### 1.2.1 Primary Health centers (PHCs)

PHC is the interface between the village community and the HCP. According to medical regulatory authority, there must be a Medical Officer and 14 Para - Medical and other staff members. It has 4-6 beds for the patients. It acts as the referral unit for 6 sub centers or dispensaries. The responsibilities of the PHCs involve curative, preventive, promotive and family welfare services. There are approximately 23,236 PHCs in India as on Sept. 2005 [2].

#### 1.2.2 Community Health centers (CHCs)

CHC is manned by 4 Medical Officers (Specialists) such as Surgeon, Medicine specialist, Gynecologist and Pediatrician, supported by 21 Para-medical and other staff members. Each CHC must have 30 indoor beds with one Operation Theatre, X-ray,
labor room and laboratory facilities. It is designed to serve as a referral Centre for 4 PHCs. There are approximately 3,050 CHCs in India as on March, 2001 [2].

Despite having such a well established protocol for providing healthcare facilities at various levels, the children in rural areas suffer immensely. Hence it is imperative to adopt and implement technology-based health care delivery systems in order to enhance accessibility for the rural population.

Figure 1.1 Rural Health Care Model in India
Though there are PHCs and CHCs existing theoretically, but providing required attention to such a large population is practically infeasible, thus agent and Multi-agent systems (MAS) are planned to bridge the gap by providing necessary attention to the medically deprived section of the society. This is required to check the high IMR. The next section introduces the concept of an agent and the multi-agent system.

1.3 Agents and multi-agent system (MAS)

Most of the researchers in artificial intelligence deal with developing theories, techniques and systems to study and understand the behavior and reasoning properties of a single cognitive entity. But with the advent of agent technology, the researchers try to solve complex, realistic, and large-scale problems. In general, an agent is anything that perceives its environment through sensors and acts or reacts through effectors with a designed goal. As an illustration, assume a human agent with the responsibility of controlling traffic. He perceives the traffic through his eyes, and controls it through predefined direction postures. The aim is to minimize the waiting time for vehicles and avoid jams. This is shown in Figure 1.2.
In terms of technology, a software agent is a computer system situated within a particular environment that is capable of autonomous action in the environment in order to meet certain designed objectives. By autonomous we mean the system is able to act without the direct intervention of humans (or other agents). It possesses control over its own actions and internal state [3]. An agent therefore is a software entity that works continuously, autonomously, and can communicate and co-operate with other agents to demonstrate intelligence [4]. In simple terms, an agent is a software component that demonstrates human like behavior.

1.3.1 Multi-agent System (MAS)

A multi-agent system can be defined as a network of agents. These agents interact with one another in order to solve problems which are beyond the individual capacities or knowledge of each problem solver agent. The main advantages of this paradigm are as follows:

- The computational resources are distributed across a network; hence it does not suffer if one of the systems gets failed.
- It provides solutions in environments where expertise is distributed.
- It models the given problem in terms of autonomous interacting systems. This is a more natural way of representing task allocation, team planning, and so on.
- It enhances overall system performance, in terms of computational efficiency, reliability, robustness, maintainability, responsiveness, flexibility, and reuse.
- It can help in encapsulating the existing systems by building a wrapper agent.

Clearly with these numerous merits, MAS can transform, if applied, the ways of modern healthcare systems acquire, store, access and communicate medical information by developing intelligent connected system.
1.4 Characteristics of MAS

The fundamental properties of the MAS are that each agent has partial information or capabilities for solving the problem; there is no centralized controlling system; computation is distributed and asynchronous and finally data are decentralized [15]. Such system enjoys one or more of the following properties as suggested in [7].

- **Autonomy:** It describes the ability to take decisions towards its goal. For instance, [14] describes an autonomous agent controlling an aircraft as it enters a specific airspace. The agent is informed about the information and the goals corresponding to the real-world aircraft. For instance, an aircraft might have a goal to land on a certain runway at a certain time. Air-traffic control agents are responsible for autonomously managing the system.

- **Collaborative behavior:** When interdependent problems arise, the agents in the system coordinate with one another to ensure that the common goal(s) must be achieved.

- **Reactivity:** Reactive agents do not have representations of their environment. They act using the 'stimulus-response' type of behavior, i.e. they respond to the present state of the environment in which they are situated. They neither take history nor plan into consideration for the future actions.

- **Knowledge-level communication ability:** For communication and coordination, an agent accepts and interprets messages from other agents using Knowledge Query and Manipulation Language (KQML). The KQML ‘performatives’ are the operations that agents perform on each other’s knowledge base. These resemble human like speech acts.

- **Inferential capability:** Inference is the act or process of deriving a logical consequence from the premises. Agents demonstrate inferential capability by acting on abstract task specification using prior knowledge of general goals and preferred methods. Inferencing techniques are broadly categorized into inductive and deductive methods.
Introduction

- **Adaptivity:** Adaptivity implies the ability to learn and improve with experience. It can be achieved by altering the problem-solving behavior of individual agents or the patterns of agent interactions. This improves the problem-solving capability with the changing circumstances.

- **Mobility:** The agents are able to migrate in a self-directed way from one host platform to another. It implies that agents can roam in the network while replicating into parallel instances, and coordinating with one another, without any centralized control.

- **Proactive:** An agent is proactive, if it persistently pursues its goals. In other words, it means an agent takes initiative on its own to solve a problem in its environment.

With these features, MAS are gaining popularity in many areas of research. The next section compares the telemedicine technology with agent based healthcare solution.

1.5 Telemedicine Versus Multi-agent based Solution in Healthcare

Now it has been recognized that the healthcare scenario in India, with respect to childhood diseases, is disgraceful and needs a solution that may work beyond the limitations of ‘lack of funds, trained staff and infrastructure’. One can think of incorporating technology based solutions. One solution is provided by telemedicine system. In this system, the HCP in rural areas sends the sign-symptom(s) to the pediatrician via internet. The pediatrician then assesses the state of various sign-symptoms and suggests the treatment. It is quite promising but suffers from the following disadvantages:
• **Lack of specific time frame:** There is no binding on the response time, i.e. the pediatrician is not bound to respond to the request made by the HCP of rural areas in a specific time frame.

• **Lack of Question-answering type of communication:** Normally, a question-answering type of mechanism is followed between the patient and the doctor before reaching to the final diagnosis. Such an interaction is found to be missing in telemedicine.

• **Involvement of a Pediatrician:** A pediatrician responds with the treatment plan or may ask for submission of further values of different sign-symptoms. Sometimes pediatrician is not physically present or there is variability in the diagnosis made by pediatricians. This complicates the whole process of delivering proper quality treatment.

• **Collaboration among different Specialist Doctors:** During complex circumstances a pediatrician usually consults number of other specialist doctors. Such collaborations are required quite often in real world problems. But telemedicine lacks an effective and efficient collaborative mechanism.

• **Money management:** Another impediment in the implementation of telemedicine is the calculation of reimbursement amount to the pediatrician. How can one measure the quality of service provided by a pediatrician? This is absolutely subjective in nature, i.e. one may favor quantitative approach or qualitative approach.

To counter all these disadvantages, one can rely on multi-agent based solution since agents are capable of demonstrating collaborative behavior, imitate as a pediatrician and can respond instantaneously. There are number of successfully implemented agent based software in healthcare and in other industries. The next section describes the application of MAS in various domains except healthcare.
1.6 Applications of MAS

MASs are employed mainly in those domains where knowledge is distributed in nature and collaboration is required to solve the given problem. Such an environment exists in almost every field. That is why, a large number of researchers are developing domain specific MAS. Brief descriptions of such systems are given below:

1.6.1 Family Financial Planning System

Nowadays, people are aware of family financial planning due to uncertain economic developments. Every day, the changes are observed in tax laws, financial regulations etc. To keep track of changes and their effect on family financial planning is important. Researchers in [7], attempt to develop a web based multi-agent advisory system for family wealth management.

1.6.2 Supply Chain Management

There is a need to coordinate among various stakeholders in supply chain management. The root cause of this problem is uncertainty in supply and demand for goods. To tackle this problem, researchers in [8] described an integrated framework based on multi-agent collaboration and case-based reasoning that can resolve various collaboration issues.

1.6.3 Urban Bus Network System

There are number of road transportation simulation tools available that help in improving service quality. But their models lack in capturing the varying travelers’ behavior. A multi-agent bus-network simulation tool which takes into account this factor, allows analyzing and evaluating a bus-network at diverse space and time scale is reported in [9].

1.6.4 Electronic selling/purchasing assistant

There are numerous internet sites that help in deciding the online purchase of product/service. These sites generate information as per the needs and interests of
individual customers. The aim of such system, say seller’s agent, is to enhance sale/merchandise or service. Similarly on the other end, there are the agents of the buyers whose goal is to serve the consumers’ interests in the best way. The aim of such agents is to reduce information overload and improve relevancy and accuracy of information [10].

1.6.5 **MAS in Construction**

MASs are also used in the automation of construction work. A research work [11] provides an overview of the same. It identifies the key issues in the development and deployment of agent-based systems, and indicates how these issues should be addressed in the construction domain. Their work presents the MAS model developed for different construction problems where agents communicate with one another in order to solve construction problems.

1.6.6 **Controlling Military Equipment**

In multi-agent system, autonomy is one of the key features. The autonomous action of an agent refers to its capability to make and influence decisions within its environment. In this rapidly changing environment, for example in managing military equipment during peace time to war time, they require adjustable autonomy. It means changing the level of autonomy of the agents during runtime as a response to changes in the environment. This scenario has been experimented and results show that by dynamically updating autonomy, the behavior of the system can be managed [12].

There are several other application areas where MAS are currently employed. This makes our belief stronger that if MASs are employed in healthcare scenario in India for tackling childhood diseases, then IMR can be reduced significantly.

1.7 **Conclusion**

This chapter describes the state of Indian healthcare with special emphasis on childcare. The daunting issues which challenge the healthcare environment are also discussed. Two
practical solutions namely, telemedicine and agent based system can be developed. There are a number of drawbacks with telemedicine whereas agent based system addresses a practical and realistic solution. That is why; it is widely used in various domains. So it is concluded that fielding MAS technology is more promising. The architecture and methodologies of MAS introduces opportunities for far-reaching societal impact towards the improvement of child health care in India.