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EPIDEMICS IN INDIA: A SPATIO-TEMPORAL ANALAYSIS

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Abstract

Hand in hand with history of any seriously infectious disease is its geography. The distribution, occurrence and spread of a disease is a geographers concern. Using the approach of spatial and temporal analysis an attempt has been made in this paper to derive spatial patterns of various epidemics in India since 1970's .The data reveals that diarrhoea and arbovirus have been major killers in India.

Spatially speaking, the states of Uttar Pradesh, Bihar, Orissa, West Bengal and Andhra Pradesh are more prone to epidemics. Their high population density and high degree of population flux explain the outbreak of disease in these states.

By and large the epidemic months are those falling between May and November. These months are most favourable for bacterial contamination of water supply and multiplication of various virus and arthropod vectors which transmit the diseases.

Introduction

Despite a long list of attainments in health achieved globally during the 20th century, the developing and the underdeveloped countries still continue to bear the burden of disease and malnutrition. India is no exception. Developed countries are facing the challenges of epidemics of non-communicable disease and injuries, where as the developing and under-developed countries are struggling with the epidemics of communicable / infectious diseases. This paper in a similar vein tries to study the spatial pattern of epidemics in India since 1970's. An attempt has been made to answer the following questions:

- What is the spatial pattern of epidemic outbreaks in India?
- Has this pattern changed over time?
- Are there predispositions in various locales for a disease to wreck greater havoc than in other places?
- Which are the potential zones of outbreak of diseases in India?

Data Base and Methodology

The study is based on the database created on disasters by Brussels University, Belgium. Tables and maps have been prepared for spatial and temporal analysis. The study has been divided into two sections. The first section deals with conceptual understanding of epidemics where as temporal analyses and the spatial pattern of epidemics in India since 1970's are presented in the second section.

SECTION - I

Conceptual Underpinning

Epidemic refers to an outbreak of contractible or contagious disease that spreads at a rapid rate through human population. Epidemics occur when an infectious disease spreads beyond a local population, lasting longer and reaching people in a wider

geographical area. When that disease reaches worldwide proportions, it is considered a pandemic.

An outbreak of an epidemic is through microbes which spread through local populations by different routes. There are millions of microbes, or microscopic organisms, most of which are too small to be seen with the naked eye. They live inside and around other living beings, including humans, in every kind of environment. There are three major groups of microbes; viruses, bacteria and protozoa. Within each group are numerous species that differ in shape, size, and structure, as well as food intake and reproductive processes. Some larger organisms, such as flukes, worms and fungi can also cause infectious diseases. Microbes spread through local populations by different routes (Jones and Moon, 1987). Various media through which they spread are:

Air : Many kinds of microbes are transmitted through the air. Crowded and unsanitary conditions increase the likelihood of airborne transmission of disease-causing microbes. Microbes also spread through air conditioners and recycled air.

Water : Microbes that flourish in water polluted by human sewage and animal waste cause many outbreaks of disease. Other disease-causing microbes live in waters where people wade, in order to fish, transplant rice crops, or swim.

Food : In the long route from farm to table, unwanted microbes may slip into the food supply - through contaminated water used to irrigate crops or during shipping, processing, and handling. The global sources of fresh fruits and vegetables pose still more problems. People in a country where food is raised may have natural immunity to a microbe that will spread disease in the country where that food is consumed. Local sanitation problems may also lead to food contamination.

Animal carriers : Insects and ticks are some of the animals that carry disease-causing microbes from one host to another while themselves remaining unaffected. Commonly called vectors, these animals can multiply and adapt rapidly to changing environmental conditions, such as new weather patterns. When such changes enlarge their habitat, humans are further exposed to the microbes these animals carry.

Trade, travel and migration : Throughout history, travelers moving about the world for work, adventure, or resettlement have spread diseases. Microbes that infest insects, rodents and stowaways—on ancient merchant ships to modern jet planes have also spread diseases. Other disease-causing microbes can lodge in the huge quantity of foods, lumber, and other trade goods that are always moving across the globe (Gellert, 1993). Today, few places in the world are truly isolated, people and goods are transported more easily, rapidly, and frequently than ever before. The enormous increase in worldwide travel and transport raises important concerns about the spread of infectious diseases.

Epidemics and Environmental Change

In every kind of environment, ranging from the inside of a cell to an entire ocean, microbes, humans, and other species interact in unique manners. Any change in the environment - such as those produced by natural causes such as drought or human activities like land clearing can upset the balance of species. In some cases, new conditions may benefit microbes causing infectious disease, allowing them to multiply rapidly and increase the risk of exposing humans who share that environment (Gatrell, 2002). Short term environmental changes as well as long term changes pose great risk, because they alter the interactions of species

living in an affected area.

Experts beleive that outbreak of infectious diseases like dengue, chikungunya and encephalitis (inflammation of the brain caused by viral infection) in India, are directly linked to global warming and climate change, which are creating favorable conditions for mosquitoes to breed and flourish (Martens, 1998). Researchers at Malaria Research Center in India opined that warmer weather and higher humidity helps vectors like mosquitoes to breed and thrive. Various studies carried out in the recent past in this center have confirmed that climate change is directly linked to the increase in vector-borne diseases in India.

Irregular weather patterns and rainfall, induced by global warming, is increasing the incidence of infectious diseases (Martens, 1998). The outbreak of dengue and chikungunya in India during 2005-06 could be attributed to the general rise in temperatures and changing weather patterns. Mosquitoes cannot breed in cold weather and the current changes in weather patterns and temperatures have created an ideal environment for them to breed. They flourish and an increase in their number translates in to an increase in vector-borne diseases. Research suggests that climate change will affect both the vectors and the infective agents that transmit infectious diseases such as malaria, dengue, fever and chikungunya (Gatrell, 2002). Malaria now infects some 300 million people each year, killing at least 2 million children and adults. Two children die of malaria every minute (Lindsay and Birley, 1996). Environmental changes, such as land-clearings in forests, irrigation canals, and rice cultivation, created patches of stagnant water where mosquitoes could breed limit our chances of defeating malaria. Besides, agricultural lifestyles encouraged people to live in greater proximity, making it easy for mosquitoes to transfer disease-causing microbes from person to person.

Hence, infectious diseases emerge, suddenly or gradually, in various environments, and may spread across a region or even the world. Weather and economics both play roles in the burgeoning and spread of a disease (Mayer, 2000).

SECTION II

Spatial Patterns

In this section an analysis has been made to discuss spatial patterns of epidemic outbreaks since 1970's. Prior to 1970's there had been six major epidemics of plague, diarrhoea and small pox in India (Table 1). The total death toll was 45,206,209 persons. Among various diseases plague was the largest killer and claimed 43,00,000 lives. There were two major outbreaks of plague in 1907 and 1920. Diarrhoea was however another major disease to kill 8,00,000 people followed by smallpox leading to 426209 deaths (Table 1).

Table 1
India: Epidemic Outbreaks (1907 – 1967)

Year	Name of the epidemic	Deaths
1907	Plague	13,00,000
1920	Plague	20,00,000
1920	Diarrhoea	5,00,000
1924	Diarrhoea	3,00,000
1926	Smallpox	4,23,000
1967	Smallpox	03,209
	TOTAL	**45,26,209**

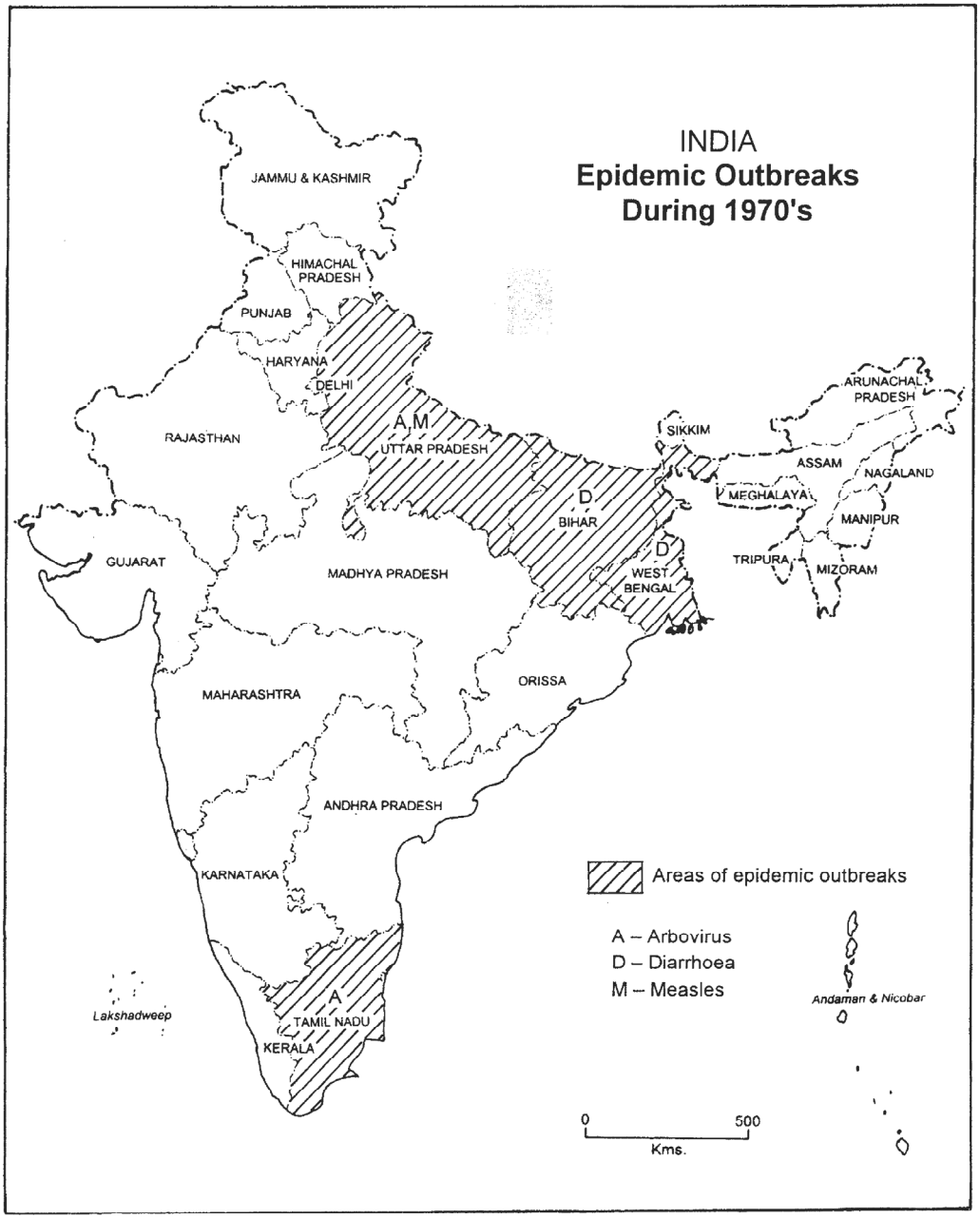
Source: Data Base on Disasters, Brussels University, Belgium.

During 1970's there were five epidemics of diarrhoea, arbovirus and measles which killed 2376 people. The states affected were Uttar Pradesh, Bihar, West Bengal and Tamil Nadu (Table 2, Map 1). As compared to

Table 2
India: Epidemic Outbreaks During 1970's

Year	Name of the epidemic	Areas affected	Deaths	Month of occurrence
1978	Arbovirus	Tamil Nadu	--	January
1978	Measles	Uttar Pradesh	48	October
1978	Diarrhoea	West Bengal	113	October
1978	Arbovirus	Uttar Pradesh	2000	October
1979	Diarrhoea	Bihar	215	August

Source: Data Base on Disasters, Brussels University, Belgium.



Source: Table 2

MAP 1

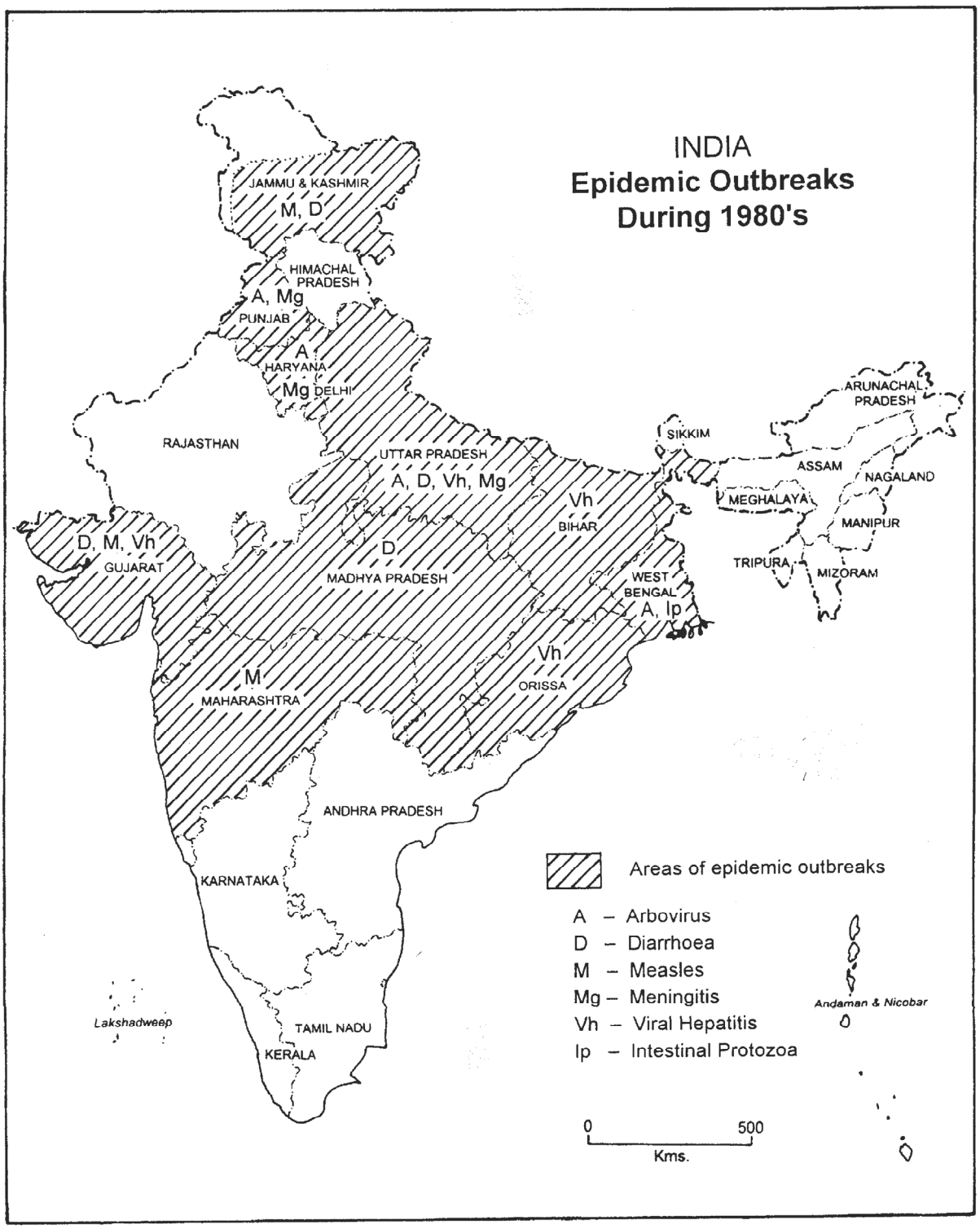
previous decades there was a considerable reduction in the death toll due to improved medical facilities. Also, there were strenuous efforts at national level to eradicate small pox and control plague. Consequently, there were no such outbreaks during 70's. However, there were diseases like measles, diarrhoea and arbovirus which inflicted upon peoples lives during this decade. Another revealing fact that emerges from Table 2 is that by and large the onset month of these epidemics was October. In fact, this is the month which marks the onset of winters and thus experiences a lot of variation in day and night temperatures. Such conditions are very conducive for microbial growth and also epidemic outbreaks. During this decade Uttar Pradesh recorded 2048 deaths from arbovirus followed by Bihar 215 deaths from diarrhea.

During the 1980's the death toll increased to 14,384 people since there were 15 epidemic outbreaks. The states affected were Jammu and Kashmir, Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Orissa, Maharashtra, Gujarat and Madhya Pradesh. The diseases that inflicted upon peoples lives were arbovirus, diarrhea, measles, meningitis and viral hepatitis (Table 3, Map 2). As compared to 70's the frequency of epidemics witnessed a three fold increase while death toll increased by 6 times. Also, there had been a considerable diffusion of previously existing diseases (Arbovirus, measles and diarrhoea) to northern, western and central India (Map 2).

Table 3
India: Epidemic Outbreaks During 1970's

Year	Name of the epidemic	Areas affected	Deaths	Month of occurrence
1980	Diarrhoea	Madhya Pradesh, Jammu & Kashmir	390	July
1980	Arbovirus	Punjab, Haryana, Uttar Pradesh	400	September
1980	Diarrhoea	Uttar Pradesh	250	August
1982	Arbovirus	West Bengal	118	October
1984	Diarrhoea	Uttar Pradesh	60	June
1984	Intestinal Protozoa	West Bengal	3290	May
1984	Viral Hepatitis	Gujarat, Orissa Uttar Pradesh	1160	May
1985	Measles	Maharashtra Gujarat	3290	May
1985	Meningitis	Punjab, Haryana Uttar Pradesh	1160	May
1986	Meningitis	New Delhi	55	January
1986	Viral Hepatitis	Bihar	210	June
1987	Measles	Jammu & Kashmir	90	January
1988	Diarrhoea	New Delhi	466	June
1988	Diarrhoea	Gujarat	445	July
1988	Arbovirus	Uttar Pradesh	3000	November

Source: Data Base on Disasters, Brussels University, Belgium.



Source: Table 3

MAP 2

Table 4
India: Epidemic Outbreaks During 1990's

Year	Name of the epidemic	Areas affected	Deaths	Persons Affected	Month of occurrence
1990	Diarrhoea	Bihar	90	18,000	August
1990	Malaria	Gujarat	58	--	September
1991	Diarrhoea	Assam	185	--	October
1994	Plague	Gujarat(Surat), Maharashtra	53	5,150	September
1996	Arbovirus	Delhi	60	900	October
1997	Leptosporosis	Gujarat	48	375	November
1997	Meningitis	Uttar Pradesh	210	--	December
1998	Diarrhoea	Assam (Adilabad, Karimnagar), Andhra Pradesh, West Bengal	679	14632	July
1998	Arbovirus	Uttar Pradesh	128	606	August
1999	Viral Hepatitis	Rajasthan (Khanpur, Jhalawar), Delhi	285		March
1999	Diarrhoea	Uttar Pradesh (Tehri Garhwal)	11	75	September
1999	Diarrhoea	Orissa	69	77,880	November
1999	Arbovirus	Andhra Pradesh	200	765	September

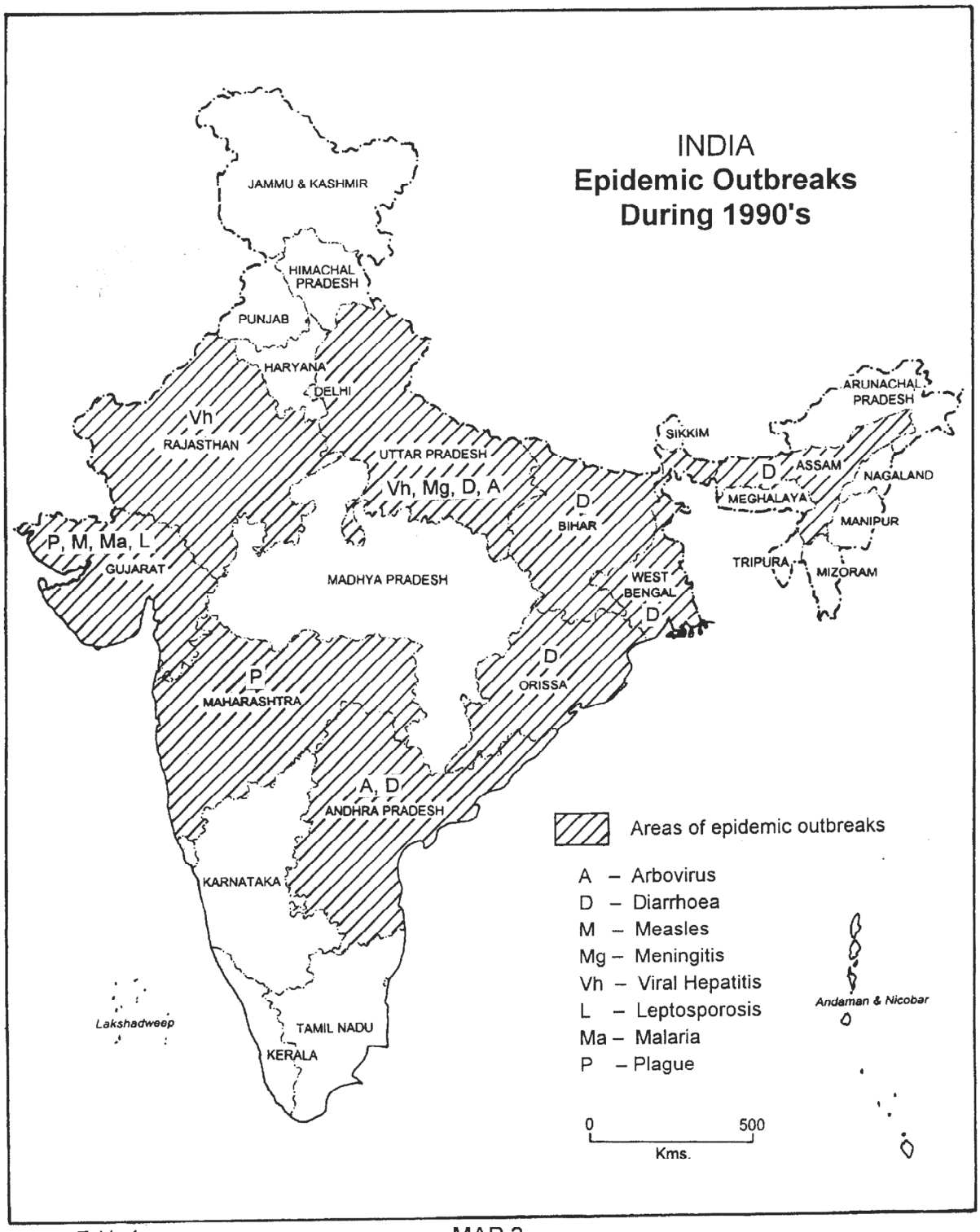
Source: Data Base on Disasters, Brussels University, Belgium.
Names in parenthesis indicate place of epidemic outbreak.

Besides, there had been emergence of some new diseases like meningitis, intestinal protozoa and viral hepatitis in different parts of India. Uttar Pradesh experienced six epidemics in the years of 1980, 84, 85, and 88 followed by Gujrat that experienced three epidemics in 1984, 85 and 88. The states of West Bengal, Jammu and Kashmir, Punjab and Haryana experienced two epidemics each while Maharashtra, Madhya Pradesh and Orissa witnessed only one epidemic each.

During the 1990's India experienced 13 epidemic outbreaks of different diseases viz diarrhoea, malaria, arbovirus, measles, plague, leptosporosis, meningitis and viral hepatitis. The states affected were Rajasthan, Gujarat, Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Andhra Pradesh and Maharashtra (Table 4, Map 3). As compared to the previous decade, there was a reduction in the number of epidemic outbreaks as well as the death toll. The death toll drastically decreased to 1581 as compared to 14, 384 during 80's. Similarly the number of persons affected also witnessed a decline from 16,065,000 persons (1980's) to 1,18,878 persons(1990's). This speaks of the efforts of the government to control epidemic outbreaks.

However, the spatial spread of diseases in states like Rajasthan and Andhra Pradesh and re-emergence of plague in Gujarat was quite serious.

The frequency of epidemic outbreaks further increased in India during 2000. In a span of just two years i.e. 2000 – 2002 there were 16 epidemic outbreaks in India. Fortunately, the death toll and number of persons affected was considerably low. The states affected were Uttaranchal, Uttar Pradesh, Maharashtra, West Bengal, Andhra Pradesh, Bihar, Jharkhand,



Source: Table 4

MAP 3

Orissa, Himachal Pradesh, Assam and UT of Delhi (Table 5, Map 4). These states recorded 275 deaths while, 66759 persons were affected by diseases.

Over the years India has been witnessing a spatial diffusion and increase in the number of epidemic outbreaks. During 70's only four states were affected while in 2002 their number almost doubled. Similarly, the number of outbreaks also tripled since 70's. Somehow, the government has been quite successful in controlling the death toll which had been drastically decreasing since 70's but the rising frequency of outbreaks and their spatial diffusion needs yet to be controlled.

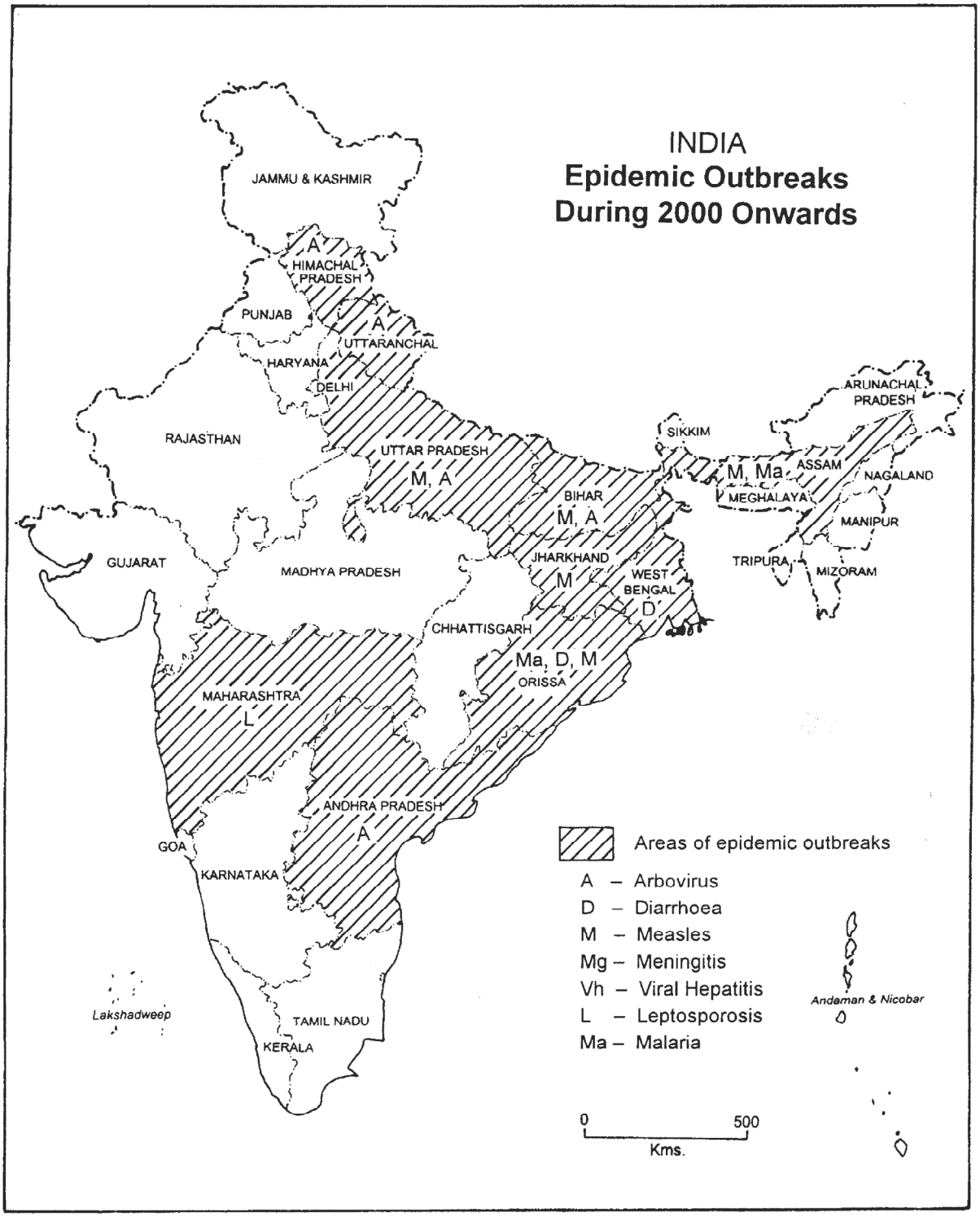
The spatio-temporal analysis reveals that the frequency of epidemic outbreaks has been witnessing an increase since 1970's. Not only the frequency but the areal extent has also increased over time. The frequency almost tripled in a span of 30 years while, the number of states affected almost doubled. Obviously, there had been a spatial diffusion of these epidemics over the last three decades. However, during this span of time there had been no epidemic outbreaks reported from Kerela, Karnataka, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Tripura and Nagaland.

Specifically, speaking, the states of Uttar Pradesh, Bihar, Orissa, West Bengal in the north and Andhra Pradesh and Tamil Nadu in the south are more prone to epidemic outbreaks. The outbreaks of various diseases in these states is explained by their high population density and high degree of population flux in Indo – Gangetic plains in the north and coastal areas in the south. The Indo –

Table 5
India: Epidemic Outbreaks 2000 Onwards

Year	Name of the epidemic	Areas affected	Deaths	Persons Affected	Month of occurrence
2000	Measles	Uttar Pradesh (Gonda & Banda district)	--	192	June
2000	Diarrhoea	Delhi	--	192	June
2000	Leptosporosis	Maharashtra (Mumbai, Thane)	27	079	July
2000	Arobovirus	Uttar Pradesh, Uttaranchal	34	116	August
2000	Diarrhoea	West Bengal	57	--	October
2000	Arbovirus	Andhra Pradesh	14	064	October
2000	Measles	Bihar, Jharkhand, Assam	13	287	October
2000	Arbovirus	Bihar (Nawadah)	19	058	October
2001	Leptosporosis	Maharashtra (Mumbai, Thane)	16	083	June
2001	Diarrhoea	Orissa	33	34,067	July
2001	Malaria	Orissa	12	24,286	July
2002	Arbovirus	Himachal Pradesh (Mandi)	--	200	March
2002	Malaria	Assam	50	4,950	June
2002	Arbovirus	Delhi	00	2,185	June

Source: Data Base on Disasters, Brussels University, Belgium.
Names in parenthesis indicate place of epidemic outbreak.



Source: Table 5

MAP 4

Gangetic plain not only continues to be the largest contiguous area of high population density and large in- migration but is also a traditionally paddy growing area. The paddy fields have to be kept under water which triggers the process of mosquito breeding and other arthropod vectors causing spread of malaria and arbovirus diseases respectively. While the levels of water quality parameters vary considerably across states, studies have found that states of Uttar Pradesh, Bihar, West Bengal, Tamil Nadu and Andhra Pradesh have high levels of sewerage, waste pollution and chemical pollution in their water resources. Hence, these states tend to be more prone to epidemic outbreaks.(National Human Development Report,2001)

The study also reveals that there are seasonal variations in the outbreak of epidemics. The epidemic most frequently occur between June and October. The months of June, July and October are very susceptible to epidemic outbreaks. June and July are hot and humid and thus conducive for microbial growth. October marks the onset of winters and thus has wide temperature fluctuations between day and night. Such changes are also helpful for microbial growth and spread of infectious diseases.

Amongst various diseases diarrhoea and arbovirus have witnessed most frequent outbreaks during 1970-2002 and hence were major killers (Table 6). Out of the total death toll one third of the deaths have been caused by arbovirus and one sixth by diarrhoea. As far as other disease outbreaks are concerned measles, meningitis, viral hepatitis, leptosporosis and malaria have also been quite frequent. Although their frequency of outbreaks is not as high as in the case of diarrhoea and arbovirus yet they have claimed more than six thousand lives during 1970-2002. This surely calls for strengthening of government's efforts for disease specific interventions and control programs.

Table 6
India: Epidemic Outbreaks (1970-2002)

Name of the epidemic	Frequency of outbreaks	Deaths
Arbovirus	13	6055
Diarrhoea	15	3059
Measles	5	3441
Meningitis	3	1215
Viral hepatitis	3	1370
Leptosporosis	3	91
Malaria	3	120
Intestinal protozoa	1	3290
Plague	1	120
Total	**47**	**18,761**

Source: Data Base on Disasters, Brussels University, Belgium.

Conclusions

Despite the successful eradication of smallpox and the control of several infectious diseases in the 20th century, India still has to combat with diarrhoea, arbovirus, malaria and measles. India is going through a period of epidemiological transition and is currently in the second stage where infectious diseases are still the major cause of death. Unfortunately, infectious diseases still persist as major health problems in spite of the adaptation of various national programs and strategies to control these diseases since last fifty years.

Improvement in sanitation and access to clean water will definitely reduce the prevalence of most of the diseases. Besides this, improving access to health care facilities; and availability of medical personnel will further help to achieve the desired results. In addition disease surveillance programmes should be further strengthened, modernized and geared up to deal with epidemic emergencies. By using data on regional landscapes, rainfall, vegetation, water bodies, elevation, dust

mapping and temperatures, researchers are able to pin point climatic conditions which are favourable for harbouring various epidemic hosts, indicating where people are at greatest risk.

Health policy makers thus have to address the burden of the existing epidemics and their re-emergence as a consequence of microbial evolution. Preventive and curative interventions need to be taken care in policy formulation. Public campaigns should be launched for disease- specific interventions and control programmes. Last but not the least, augmented political, financial and technical support should be ensured wherever and whenever it is required. These are the emerging challenges that need to be tackled in the new millennium.

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