CHOLERA INCIDENCE IN THE STATE OF TAMIL NADU, INDIA

Report Submitted to the

International Development Research Center,

Ottawa

by

Balasubramanyam Hyma
Department of Geography and Renison College
University of Waterloo
Waterloo, Ontario.

December, 1975.

ACKNOWLEDGEMENTS

The author is indebted to the International Development Research Center, Ottawa, Canada, for providing her with a travel-research grant for the period 1974-75. It made this research project, dealing with the current status of two selected communicable diseases, cholera and malaria, in Tamil Nadu, possible. The author also acknowledges the support of the University of Waterloo - Canada Council travel grant which helped her to complete the field research in India during the summer of 1975.

Appreciation and gratitude are extended to Dr. C. A. K. Shanmugam, M.D., Additional Director of Health Services and Family Planning, Government of Tamil Nadu. Without his assistance, co-operation and intimate knowledge of the study area, an empirical field research of this type would have been impossible in an area with limited documentary sources. His sustained interest and effort in guiding this research has been invaluable. Appreciation is also owed to Mrs. Mercy, Statistical Officer in the Epidemiological Division of the Directorate of Health Services and Dr. Kamal Sheriff, the Epidemiologist for generously giving their valuable time and helping our research assistants to compile data from public health records with least delay possible. Dr. Sumathi Rao, Health Education Officer, is also thanked for providing us with the information on this subject.

Because the length of field research involved more than anticipated, Dr. A. Ramesh, Head of the Department of Geography, University of Madras, consented to be my research associate in the field. Hence, this report ended up as a joint effort by both Dr. Ramesh and myself. I am grateful to Dr. Ramesh for not only letting me use the facilities of the Geography Department during the field research in Madras, but also for providing his valuable time, continued support with useful suggestions, and discussions at all stages of the field research in Madras. I also owe my immense thanks to our most persevering and hard-working graduate research assistants, Miss K. G. Rukmani, and Miss T. Geetha, for having spent considerable time in the frustrating and laborious job of searching and compiling raw data from the original Public Health returns, and turning the data into readable form. Their valuable assistance in the preparation of tables and maps is also gratefully acknowledged.

I appreciated the help received from Ms. Sue Blinn, a free-lance editor in Pittsburgh for editing the manuscript.

My thanks are also extended to Gary Brannon, Chief Cartographer, in the Department of Geography, University of Waterloo, for giving his time generously in the final drafting of the maps.

Finally, my good friend Suzanne Cowls, in the same Department, is thanked for her dynamic efforts at typing and reproducing this manuscript in final form.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (continued)

INTRODUCTION

This research paper presents a review of both the epidemiology and the problem of endemicity of cholera in the State of Tamil Nadu, India, during the period 1961-1974, for the purpose of abetting the move toward more effective prevention and control methods and the eventual eradication of the disease.

One objective of this study is to identify those geographic areas in the State of Tamil Nadu, India, in which significant levels of cholera were found during the period 1961-1974. Concentrating mainly on aspects of medical geography, this research paper describes the extent of areal and seasonal variations in incidence and mortality, information necessary for predicting cholera patterns in future control and prevention planning.

Another objective of this research is to determine the extent to which there has been reappearance or re-establishment of cholera in areas from which it had apparently disappeared or declined some years ago. Some environmental and administrative problems related to its reappearance are considered, particularly in limited endemic areas and in scattered areas in the form of epidemics. In a study of disease patterns in the period 1955-1964 by the World Health Organization (W.H.O.), it is shown that the recrudescence of certain diseases regarded as either quiescent or under control is a troublesome event; but even more troublesome is the extention of the communicable diseases such as cholera El Tor, infectious hepatitus and hemorrhagic fever within or beyond the territories in which they usually occur. The study noted the similarity between the menacing extention of recent cholera El Tor from the Philippines to Iran and Asiatic cholera in its classic period (World Health Organization, No. 55, 1967, pp. 57-58). Although mortality from cholera has declined considerably throughout this region in recent years, incidence rates have risen. Characteristics of cholera differ from area to area, adding to the complexity of finding effective prevention and control methods. A study of the geographic distribution and incidence trends of cholera is necessary in tracing areal as well as seasonal patterns, vital information for planning the health care program of a state.

Both the epidemiology and the problem of endemicity of cholera, with particular reference to the study area, are presented, including the probable source of epidemics, the role of carriers such as migrants, water, food, flies, in the transmission, and the economic and social aspects of the disease.

Prevention is an important aspect of medical geography, as well as being another objective, for there is virtually no absence of serious infectious diseases today. Even if disease is not present, there is always a possibility of reinfection; this depends upon the immunity status of the population and the reservoirs of susceptibles. The nature and spatial extent of prevention, control and surveillance procedures will play an important part in eradicating communicable diseases.

One final objective of this research paper is to present an appraisal of public health planning, program and implementation, and health care facilities which the government and the local authorities have developed in response to growing awareness of health concerns. Environmental health measures in cholera control programs are analyzed. Health services presently available in certain areas are assessed, as are the future health needs of people living in those areas. Some practical and administrative difficulties of communicable disease control are considered, as are the elements of surveillance activity.

Cultural and social factors play an important role in health planning. Studies have shown that villagers in the tropics are unconcerned about their physical health and well-being and come to accept the disease state as their natural one (Fonaroff and Fonaroff, 1966, p. 67). In all of these diseases there is resistance of the population to methods of control because of their cultural beliefs, habits and traditions. An appraisal of administrative, economic and social aspects of public health activities will provide an additional tool in overcoming these difficulties and facilitating future health programs within the study area.

PART I

THE EXTENT OF THE PROBLEM

A Survey of Pertinent Literature

India, regarded as the world's endemic home of cholera, was the source of six pandemics between 1817 and 1923 (Pollitzer, 1959). There are areas in India where cholera has never died out completely, while in others, it was absent for several weeks or months (Bellew, 1884; Rogers, 1926; Russell and Sundararajan, 1928). Cholera has remained endemic in certain parts of India, although the reason is not yet fully understood. Marked fluctuations in cholera incidence were observed from year to year in most identified endemic areas; the epidemic areas experienced a six-year periodicity (Russell and Sundararajan, 1928). Russell and Sundararajan conclude from statistical work on the epidemiology of cholera in India that the association of high humidity with high temperatures, accompanied by intermittent rains, forms the most favorable atmosphere for the development of the disease (1928).

Hesterlow's study of cholera mortality figures for districts of the Madras Presidency (British India) for the period 1881-1925 shows, with the use of maps, a different picture of endemicity. The average death rate figures for the 65 years from 1881 to 1925 identify the district of Tanjore as highly endemic, followed by the Ramnad and Madurai districts (Hesterlow, 1929, p. 82). There are endemic centers from which epidemics spring at short intervals with no single cause; these periodic waves of disease are preceded by conditions too complex to be analyzed using available data. Many factors add to this complexity such as individual susceptibility, foci of infection, favorable atmospheric conditions, group gatherings at fairs and festivals, carriers, unsanitary habits, etc. (Patnaik and Kapoor, 1967, p. 6).

In a study covering a period from 1900 to 1945, Swaroop and Pollitzer distinguish between endemic and epidemic areas of cholera in India, including three administrative districts of Tamil Nadu (Appendix I), namely Thanjavur, Tiruchirapalli and South Arcot in the Cauvery deltaic region (Pollitzer and Swaroop, 1954). The distinguishing features of known and probable cholera endemic areas are: (1) they are deltaic areas; (2) they are generally within 100 miles of the sea coast (such as Madras, Andhra Pradesh, Orissa, West Bengal, Burma, Thailand, Indo-China, China, etc.); (3) the water sources in such areas have higher salinity and on occasion high pH; (4) population density is generally higher, and human diet consists mainly of rice; (5) the temperature and humidity are generally high (Seal, 1960, p. 3).

In a study of specific mortality figures of the different states of India (mainly referring to British India) between 1866 and 1948, Seal observed that: (1) cholera has been prevalent more or less in all states every year; (2) the incidence was remarkably severe in the 1900's, affecting most severely the states of C. P., Bombay, Bihar and Punjab; (3) mortality from cholera in India was highest during the period 1890-1969; (4) in 1943, Bengal was very badly hit by cholera due to famine, and there was a widespread epidemic throughout India; (5) a high death rate due to cholera existed until 1919, after which a downward trend was noticeable continuing more markedly since 1932; (6) the states which showed marked yearly variation of cholera mortality were C. P., Bombay, Bihar, Punjab, Madras and U. P. (p. 4). In 1877 Madras had the highest incidence, 12.2 per mille, ever recorded in India, while in 1900 Bombay recorded a rate of 8 per mille. The variation in Bengal was not marked but the severest epidemics were recorded here in 1906, 1928 and 1943 (mortality rate 3.5 mille) (p. 4).

Delineation of endemic tracts in the Madras Presidency has been attempted by several authors studying epidemiology of cholera in the area during the period 1925-1951 through statistical analysis of cholera mortality figures for the individual districts of the State of Tamil Nadu. Based on the high mortality figures and the high persistence rate for a 30-year period from 1896 to 1925, A. J. H. Russell concludes that cholera is, to a certain extent, endemic in the deltaic tract, which includes the major portion of the Tanjore district and smaller parts of Trichinopoly and South Arcot (Russell, 1928). A six-year epidemic cycle in the State of Madras for a 30-year period was explained by A. J. H. Russell as due to immunity having been developed by the survivors of cholera attacks. Raja examined the mortality figures for cholera in different districts of the Madras Presidency for the 15-year period 1927-1941, i.e., following Russell's period of investigation. Raja corroborated Russell's observations that cholera persisted longest in the tract encompassing the districts of Tanjore, South Arcot and Trichinopoly (Swaroop, 1951, p. 186). A later study by Swaroop in 1951 confirmed through the statistical analysis of mortality figures that these districts comprised a tract exhibiting favorable conditions for the persistence of cholera infection, thereby indicating endemic foci in that location (p. 196).

With regard to the question of origin, Russell found that an invasion ultimately traceable to Bengal preceded every cholera outbreak in the Madras Presidency (quoted by Swaroop, 1951, p. 185). Although almost all the major epidemics invaded the Tanjore, South Arcot and Tiruchirapalli districts, not one is known to have originated there (Swaroop, 1951, p. 185). Swaroop notes, "In the year 1941, in connection with a field inquiry in the Madras Presidency, the Cholera Advisory Committee of the Indian Research Fund Association observed that the Tanjore district had been remarkably free from cholera during the previous two years and expressed the opinion that the endemic status of the area was doubtful and required re-investigation" (Swaroop, 1951, p. 185). Swaroop concludes that no major epidemic in the Presidency is known to have originated in the so-called local endemic zones, but, instead, in the North, i.e., generally proceeding through the Hyderabad State. Once infection is imported, it has a tendency to persist longest in the two above-mentioned groups of districts (p. 196).

A comprehensive statistical study by Patnaik and Kapoor assesses the cholera incidence in different States and districts in India during the years 1954-1965 and reports that during the years 1961-1965, India alone was responsible for nearly 74 percent of the world's cases and from 84-90 percent of the total world's deaths from cholera (p. 26). Having analyzed the pattern of cholera incidence in India during 1900-1963, the study concludes that the decline in incidence was particularly remarkable after 1947, as was the lengthening of the inter-epidemic interval.

Still, incidences of cholera are reported every week from India. Some important factors which favour the persistence of cholera in India, singularly or jointly, are: (1) close proximity to endemic and potential epidemic areas, both within the state and in neighboring states; (2) delayed and defective notification; (3) poor and primitive environmental conditions, including water supply and sewage system; (4) lack of facilities for epidemiological investigation and statistical intelligence; (5) lack of support for laboratories and ambulance services; and (6) lack of facilities for isolation and treatment. Traffic (road, rail and river) plays an important role in transmitting disease, as do public gatherings at fairs and festivals (Patnaik and Kapoor, 1967, p. 26).

The El Tor biotype invaded India in 1963-64 from its endemic foci in Sulawesi, through southeast Asia. Since 1965, incidence of cholera El Tor has been reported from Andhra Pradesh, Bihar, Delhi, Kerala, Madras, Maharashtra, M. P., Mysore, Punjab and West Bengal (Patnaik and Kapoor, 1967, p. 27). The incidence of cholera as reported from each State during the period 1956-1966 indicates that the highest contribution to the death total was made by Bihar (20.84 percent), followed by the States of West Bengal (16.57 percent), Andhra Pradesh (13.52 percent), Maharashtra (12.9 percent), Madras (10.07 percent), Orissa (6.0 percent) and Mysore (5.0 percent). These seven States containing endemic areas of cholera were responsible for 87.72 percent of the total cases and 88.68 percent of the total deaths reported in India during 1956-1966 (Patnaik and Kapoor, 1967, p. 11). Madras ranked seventh (12.54 percent) among the nine states which reported higher average annual attack rates per 100,000 population during 1956-1966, Pondichery (28.21 percent) and West Bengal (20.90 percent) occupying the first two ranks. Similar ranking could be found for average annual death rate during 1956-1966, with Madras (4.86 percent) and Pondichery (8.84 percent) and West Bengal (7.95 percent) (Patnaik and Kapoor, p. 12). This study also pointed out four hyper-endemic districts in Madras State, namely, Madras City, South Arcot, Tiruchirapalli and Tanjore, as among the 43 districts identified under the hyper-endemic categories of 314 districts in India during 1954-1964 (p. 27).

Following this study by Patnaik and Kapoor (1967), there has been no other comprehensive literature analyzing the geographic trends and distribution of cholera mortality in India. However, mention should be made of A. T. A. Learmonth's study on Medical Geography in India and Pakistan, 1958-1961, dealing with an analysis of death rates for selected diseases in the former British India for a twenty-year period (1921-1940) (Learmonth, 1958). A census report from Madras on demography and vital statistics has been presented using tables, charts and maps, and statistics on the causes of death related to the most important diseases of Tamil Nadu. This document also discusses at length the problems related to the control of communicable diseases including cholera in the State. Mortality statistics are given for the period 1900-1960 for the different districts of Tamil Nadu (Madras, Demography and Vital Statistics, 1965). However, little or no work has been found dealing with the details of the geographic distribution and trends of such diseases after 1960.

Significance of the Cholera Problem and the Geographic Study of the Disease

When a disease is always present at a relatively low level, it is endemic; however, endemic diseases do not remain constant in any one place, but are liable to fluctuate in incidence, widely at times. The greatest incidence constitutes an epidemic. Just how great the maxima must be to constitute an epidemic is a matter of judgement; no definition of an epidemic is precise and none have received general acceptance (Davey and Wilson, 1971, p. 14).

The studies reviewed have indicated that in certain parts of India cholera is almost endemic, i.e. it is present in some form or other throughout the year, but generally occurs in epidemic waves at intervals, and that this infection does not persist from one season to the next (Patnaik and Kapoor, 1967, p. 7). Known endemic areas in India are found in U. P., Assam, Madras, West Bengal, Mysore and Maharashtra. When an epidemic occurs, endemic areas often aid in rapidly extending reservoirs of infection, primarily within the state, and subsequently outside the state (Patnaik and Kapoor, p. 7). The spread of the disease is always very rapid, and preventive measures must be taken early to prevent the loss of human lives. When control measures are relaxed, cholera epidemics re-occur, for example, at fairs and festivals, where large groups of people congregate (Mathur, 1973, p. 75).

India, being subjected to both the endemic and epidemic situations, must tackle them simultaneously. Handling a true epidemic situation is far simpler than handling an endemic situation; in fact, the greatest problem cholera presents is its endemicity (The Indian Journal of Public Health, 1959, p. 2). While the epidemic situation involves measures of control and prevention, an endemic status requires preventive and eradication measures, total identification and removal of endemic foci. To do so involves detailed micro-level studies about the cause of endemicity and these needed studies are lacking today in many endemic areas. Some major characteristics of endemic areas, noted by Pollitzer and Swaroop, are not totally responsible for the persistence of the disease. The population's lack of health care knowledge contributes to the perpetuation of this infection as do certain social and economic factors. Public health control and prevention measures that have been taken so far have failed; they are more applicable to the epidemic situation than the endemic. The real need is to develop measures to eradicate the endemic foci. Data on the different aspects of the cholera problem have been made available through the large amounts of literature written on the subject, but so far no clear cut measures have been found to deal with the problem of endemic cholera.

W.H.O. Chronicle states that a misconception about cholera is that standards of environmental health have so improved that the chances of its spreading in the great pandemics are negligible. In fact, the standards of environmental health in many of the countries through which cholera is spreading at present have changed little, if at all, since the 19th century. In some towns, as a result of the population explosion and the influx of the people from the rural areas, standards may well be lower. Moreover, the best sanitation installation and the most enlightened public health measures remain ineffective when they are not accepted by everyone, improperly used or accompanied by unsuitable personal hygiene (W.H.O. Chronicle, 1966). Mortality reduction, in developing countries where it has been seen, has been mainly achieved through extensive use of modern medicine and other prophylactic measures. The battle to reduce disease has hardly been successful even with modern methods, because the environment remains highly conducive to the spread of infectious diseases. "The history of the W.H.O. smallpox eradication illustrates the point that although a disease may be successfully controlled or even eradicated by means of vaccination, unless the environment is changed so as to reduce the likelihood of the spread of the disease, any importation will result in new epidemics or even the regression to an endemic state" (Robinson, et.al., 1974, p. 288). In this context, a study of the geographic pattern of disease distribution and the trends in distribution assume an important role in planning and developing health care programs. Endemic areas in many parts of the developing world are lacking the necessary research in medical geography; great potential exists for this research, which could contribute significantly to solving health problems related to communicable diseases.

It is important at this point to underline the need for applied medical geographic research. "Medical geography studies patterns of distribution of human disease, why particular diseases are localized in particular groups of people, when they are most likely to occur and how they spread. Medical geography attempts to relate differences in disease incidence to differences in local environments. It differs from epidemiology because it emphasizes areal distribution patterns of disease, the areal spread of diseases, the areal variability of disease and the areal relationships of disease with factors or phenomena of the environment" (Howe, 1972, p. 304). This paper emphasizes the identification of areal patterns and changes, if any, as well as seasonal variations in both time and space in terms of the incidence of cholera. As Howe points out, "areal variations in disease incidence afford pointers to previously unsuspected environmental relationships. As modern epidemiology strives more and more to discover links in a causal chain, the approach of the medical geographer may prove a useful complement to genetic and clinical research in the laboratory" (p. 307). Armstrong suggests that research in "medical geography adds strength to the locational aspect of all kinds of health planning, particularly in relation to the location of resources, service areas, and community assessment ... It gives a description of the assemblage of known health problems in an area, as related to the physical, biological and cultural spheres of the environment. This helps to identify those health and environmental factors which are area wide, those which are centered in sub-areas or segments of the community, and those which extend beyond the planning area. Study of the geographical association of these factors thus reveals alternative points of intervention for handling known health problems and indicates where future problems might emerge" (Armstrong, 1972, p. 128).

It is hoped that a case study of this type, related to geographic incidence and mortality patterns in different parts of the study area, will provide further challenges to research in medical geography studies at micro-level to provide a better understanding of disease incidence and prevention.

PART II

GEOGRAPHIC DISTRIBUTION OF COMMUNICABLE DISEASES AND HEALTH STATISTICS

The health status of populations relative to communicable diseases has been assessed by observing the geographic distribution of mortality and morbidity patterns. In epidemiology as well as in medical geographic research, statistical techniques are employed to measure how many people are infected at a given time and how wide an area is involved. According to Holland, the first assumption on which epidemiology is based is that diseases, accidents, and congenital defects are not randomly distributed in the community. He asks "What are the reasons for the non-random distribution of a given disease?" "Why do some people get it and some not?" (Holland, 1970, p. 15). In answering he attempts to relate the quantitative distribution of diseases in population groups to the factors which might influence distribution -- factors such as suspected agents, environmental conditions, and host susceptibility. The results enable epidemiologists to formulate and test hypotheses concerning the causation of disease. Holland also observes that the incidence of disease can be modified by intervening between man and his environment; this intervention is implicit in the concept of disease prevention (p. 15).

Some diseases have predictable seasonal variations and, like cholera, occur in a cycle of several years. A disease process is dynamic, changing spatially in intensity and with time. The data become interesting if cases occur relatively near one another both in time and space (Holland, 1970, p. 7).

Certain data are essential in order to assess or measure the health status of the population of an area or to compare conditions affecting health in various areas or in different years. First, there must be well-developed and understood criteria as to what constitutes a valid diagnosis. Clinical as well as statistical data must be taken into account when comparing one area with another. Second, results of studies must be available for study and review. Even though diseases have been studied by biologists, epidemiologists, and medical doctors, in many cases in the developing countries, the detailed results of their research have not been clearly reported. Until this is done, many factors of incidence and prevalence cannot be interpreted. In addition, data from clinical sources such as physical examination or pathological lab, immunological reaction, bacteriologic array and autopsy are limited (Banta and Fonaroff, 1969, p. 88). Information can, however, be conveyed with simple graphs of epidemic curves and the mapping of disease patterns, allowing for increased understanding of disease process.

Most countries of the world have a system for the routine collection of data which is helpful in assessing health problems quantitatively. An examination of mortality and morbidity statistics, and their areal distribution, provide information helpful in understanding the incidence, spread and causes of diseases. This information is important to the local health authorities in their efforts to control prevalent diseases. Even though the disease may not be readily understood, health problems can be assessed quantitatively through such data (Uemura, 1970, p. 55).

The Importance of Health Statistics

Planning for medical and health services requires a thorough knowledge of disease distribution patterns. Health statistics, a valuable source of information cover such data as: (1) the health status of a given population; (2) mode of living; (3) the cause of deaths; (4) the intensity of disease; (5) geographic areas of distribution, and (6) the availability of medical services. Health statistics are a means to measure not only health, but also the factors influencing it and the steps which the community takes to produce it (Madras: Demography and Vital Statistics, 1965, p. 239). Included in the statistics are factors such as water quality, sanitation, drainage facilities, waste disposal, food control and nutrition, and facilities such as hospitals, clinics, laboratories, dispensaries, immunizations and health centers.

For the State of Tamil Nadu, the subject of this study, health data are not readily available according to both Madras Cenus Report (p. 240) and the author's recent experience. The data are obtained from public health records with great difficulty. It is reported by the Census document that the validity of the data may be questionable (p. 240). Further, the data are scattered among many governmental departments. For instance, hospital statistics are generally compiled by the Medical Department whereas those relating to vaccination are available in the Public Health Department. The Education Department is concerned with school medical inspection and record data and information on this subject. Municipal authorities are responsible for health data collection particulars of the institutions run by them; however, many private and voluntary organizations do not furnish any statistics to the authorities concerned. Therefore, the compilation of a complete list of existing health statistics often requires many months of search in publications and reports (p. 240).

Providing for health services again calls for a rationale for spending scarce capital resources in development planning. Madras Census Report illustrates this problem:

> "No country, however rich, can afford to spray anti-malaria insecticides in all habitations throughout its territory. We need some measurement, in terms of incidence and mortality, of where and to what extent malaria is distributed; and when the control programme is under way, we need statistical measure of its effectiveness; and when once the disease is eradicated we must keep it under check by knowing where fresh cases occur. Even the existing programmes need a periodical review if they should prove effective and quite often a skilled application of vital and health statistics is necessary to know what services are needed and how they are meeting current needs"
>
> (p. 238).

Sources of Information and Data

The morbidity and mortality of cholera in the major administrative districts of the State of Tamil Nadu were studied for the period between 1956-1974 utilizing monthly statistics. Sources available for compilation of mortality and morbidity statistics are: (1) public health records, containing notification of diseases in different administrative divisions; (2) the Census of Madras, and (3) hospital in-patient records. Hospital and clinic sickness and deaths records are not always accessible, nor are they considered consistent or complete (Demography and Vital Statistics, 1965, p. 240). Therefore, this study uses, as its main source, the annual statistics published by the Public Health Department of the Government of Tamil Nadu; specifically, these statistics are to be found in an annual publication entitled "Report on Health Conditions in the Madras State" available from 1955 to 1970. It contains selected health data for districts, and municipalities with populations of 30,000 and above.

No published data are available for the smaller administrative units such as panchayat unions, taluks or villages. However, the data from taluks are maintained in raw data sheets at the Statistical Division of the Directorate of Public Health. No attempt has been made so far to have these particulars compiled and consolidated in a tabular form.

The Public Health reports contain statistics of live births, still births, deaths by causes and by age, and vaccinations. Figures for deaths due to cholera, smallpox, plague, fevers (including malaria), dysentery, diarrhoea and respiratory diseases are given by months for each year for each district unit, from 1950 to 1970. Morbidity data for cholera are available only from 1961 to the present; previous reports were found to be missing.

The Census of Madras (Demography and Vital Statistics), published in 1965, is the only other valuable publication containing comprehensive information on health and vital statistics of the state of Tamil Nadu and selected aspects of the Public Health systems in the State. It presents an analysis of data on mortality rates for important diseases, such as cholera, smallpox, malaria, fevers, dysentery, and diarrhoea for various districts of Tamil Nadu between 1900-1960. After 1960, no published work or documents were available on mortality patterns of communicable diseases other than the annual public health reports. Hence, intensive field work was necessary in order to compile statistics for this study from public health returns from 1961 to 1974.

Notification and Categorization of Diseases

The document Madras: Demography and Vital Statistics reports that the Public Health Department of the Madras State was begun in 1864. Compulsory notification of infectious diseases was first introduced in England in 1876 and this Act was the basis for similar enactments elsewhere, including India. In 1897, India passed the Epidemic Diseases Act which allows the government to take special measures and prescribe temporary regulations if an outbreak of any dangerous disease is threatened (Demography and Vital Statistics, p. 116).

A "dangerous disease" is defined in the preliminary chapter of the Madras City Municipal Act of 1919, and again in the Madras Public Health Act of 1939 (Act III) defining the following as infectious diseases: acute influenzal pneumonia; anthrax; cerebro-spinal fever; chickenpox; cholera; diphtheria; enteric fever; leprosy; measles; plague; rabies; relapsing fever; scarlet fever; smallpox; tuberculosis; and typhus. Local authorities were empowered to treat such diseases, to prevent them from spreading, and to investigate the cause of such mortality that occurred; health officers were given powers to appoint additional staff and to obtain necessary medical supplies. This Act defined the following diseases as notified infectious diseases: cerebro-spinal fever; chickenpox; cholera; diphtheria; leprosy; measles; plague; rabies; scarlet fever; smallpox, and typhus (p. 34).

Under Act 1939, the health officers were empowered to occupy houses to prevent the spread of infection. "Every medical practitioner who, in the course of his practice, becomes cognizant of the existence of any notified disease in any private or public dwelling other than a public hospital and every manager of any factory or public building, every keeper of a lodging house, every head of a family and every owner or occupier of a house, who knows or has reason to believe that any person in the premises under his management, control or occupation is suffering from, or has died of a notified disease, shall, if the case has not already been reported, given information of the same with the least practicable delay (a) in municipal areas, to the executive authority, the Health Officer of a Sanitary Inspector; and (b) in non-municipal areas to the Health Officer, a Health or Sanitary Inspector or the village headman" (p. 35).

In Madras, the vital statistics returns for municipal and non-municipal areas note cause of death particulars. The classifications included in the monthly return of the municipalities are as follows (Demography and Vital Statistics, p. 129): (1) infectious diseases: cholera; chickenpox; diphtheria; measles; plague; smallpox; typhoid or enteric fevers; others; (2) fevers: malaria; influenza; relapsing fever; kala azar; rheumatic fever; others; (3) respiratory diseases; tuberculosis; pneumonia; others; (4) alimentary system; dysentery; diarrhoea; others; (5) diseases of the liver; cirrhosis; others; (6) circulatory system; heart disease; arteriosclerosis; others; (7) genito-urinary diseases (excluding venereal diseases); Bright's disease; (8) venereal diseases; syphillis; gonorrhea; others; (9) diseases of the nervous system; convulsions; cerebral hemorrhage.

In the rural areas where Act III of 1939 is in force the following classification of deaths are recorded (Demography and Vital Statistics, pp. 129-130): (1) cholera; (2) smallpox; (3) plague; (4) relapsing fever; (5) malaria; (6) other fever; (7) dysentery and diarrhoea; (8) respiratory diseases; (9) injuries (suicides, woulds and accidents, snakebite, killed by wild beast, rabies, deaths from childbirth); (10) all other causes.

The Census document provides us with a look at the actual process of notification from the village level to the State. Legal provisions for notification of diseases are not always followed for various reasons such as lack of adequate laboratory and other facilities for diagnosis of disease and ignorance of the population. However, people are generally familiar with the manifestations of the three epidemic diseases - cholera, smallpox and plague, and do report these occurrences though often inaccurately. Cases are reported to the village headman who records them in a special register according to departmental instructions. Immediately, the village headman begins sending daily reports of attacks and deaths from these three diseases to both the Tahsildar, the administrative officer in charge of the taluk, and the Health Inspector of the region. The Tahsildar in turn sends daily reports to the Office of the Director of Public Health in Madras City where they are consolidated. Daily bulletins and weekly statements stating the number of attacks and deaths from these diseases are issued to various health offices in the district and in the case of epidemics to other neighbouring States (p. 8). Although reporting is incomplete, the consolidated figures give a fairly accurate picture of the extent and intensity of prevalence in the district.

There are many defects in the registration systems, resulting in inaccuracies. For instance, the man who reports deaths, and who is probably making the diagnosis, is the village headman. First, while he is expected to carry out registration of vital events, he is mainly preoccupied with revenue work and has little time for vital registrations. Secondly, in most of the villages, the village headman is illiterate and can hardly be expected to diagnose the cause of a person's death and often he reports 'fever' or 'not known' whenever he has a doubt. There is also a tendency on the part of many to classify "smallpox" under "other causes", "fever" or "measles" and to register "cholera" as "diarrhoea" or "dysentery" (p. 137).

Vital Statistics of Cholera

The incidence of cholera will eventually tell when, where, and why an outbreak is likely to occur. The Census document notes that "the accurate review of cholera mortality together with ancillary enquiries of a local nature should help the health officials to trace the principal foci of cholera and take suitable action at the places where outbreaks are likely to occur" (p. 169).

The Census document notes that reports of attacks and deaths from cholera are often delayed both in dispatch and en route, and a fortnight or month can elapse before the report reaches the Director of Public Health. Such delays in reporting the earliest occurrence of the disease result in an outbreak remaining unchecked until it has reached epidemic proportions and losing all chance of tracing the original source of infection. If the village officers, health inspectors and Tahsildars do their respective jobs on a timely basis, a district health officer would learn within a few hours of an occurrence and proceed at once to the infected town or village; here he could investigate to correct possible mistakes in diagnosis, arrange for reports of all deaths and attacks to be promptly and accurately registered, and to decide what immediate health measures and staff are required (p. 169).

It is encouraging to point out that with the introduction of seven new mobile epidemic control units, three epidemic control units and a cholera combat team in three endemic districts of the State, the systems of notification, diagnosis, control and prevention have considerably improved since 1969 in the State of Tamil Nadu.

Limitations

The purpose of this section is to identify and bring to the attention of medical geographers some of the problems in a developing country or state that influence the type of data frequently used in research in geographic aspects of disease distribution.

This study has had to make use of available data from public health records even though such records are often incomplete and contain many errors. Therefore, mortality and morbidity statistics must be looked upon as relative and must be used cautiously, allowing for errors in the data. As was mentioned earlier, complete and accurate statistics, even fairly accurate records of diseases such as a cause of death or sickness, are rare. When used for this purpose, therefore, sickness and mortality statistics must be looked upon as relative, and as an index rather than an absolute representation of the frequency of disease. Observations must be studied over a sufficiently long period of time to minimize errors in assessment.

The data may be more reliable in areas served by better health facilities (e.g., municipal towns and corporate cities), and areas with fairly good registration systems. The mortality and morbidity statistics may also be slanted by inaccessibility of health care to the majority of people who form the disease reservoir and the different levels of quality care in urban and rural areas (i.e., mortality statistics would exhibit relatively large amounts of urban data). The uneven nature of aggregate data (rural and urban) make accurate deductions difficult. Death registration is more reliable in the municipal areas than in the non-municipal areas because the general educational standard of the public, including registration officials, is higher. Health officers, sanitary inspectors, and other health staff in municipalities are more competent than village headmen in identifying each of the causes. In summary, greater reliance can be placed on the cause-of-death statistics for municipal areas than for rural areas (Demography and Vital Statistics, p. 138).

Morbidity statistics are found to be less reliable than death statistics because recovery from disease usually renders its detection at a later date impossible and retrospective questioning is often useless (Robinson, et.al., p. 283). Miller notes that another major deficiency of morbidity and mortality statistics is that they have no means of conveying characteristics of individuals, which may influence the development of the disease. For example, "population surveys of specific immunity, measured in terms of serum antibodies may give useful information about the prevalence of infection, as well as other data of clinical and epidemiological value. But little is known about the way in which amounts of serum antibody are related to past infection and future susceptibility to illness. This question has considerable practical importance in planning immunization and predicting the likely course of epidemics" (Miller, p. 19). A World Health Organization report indicates, "assessment of the prevalence of true cholera in infected areas is nearly impossible. The lack of adequate laboratory facilities does not allow the examination of more than a small fraction of classical cases. Moreover, the presence of non-vibrio cholera in many areas make it impossible to estimate the prevalence of vibrio cholera from statistical data based on clinical diagnosis" (World Health Organization. No. 352, 1967, p. 6). Fear of economic sanction and social consequences which may follow a report of cholera prevent many local authorities from admitting the presence of cholera in their areas unless unmanageable outbreak has occurred. Some cases and deaths that might be due to cholera are then attributed to diarrhoea and gastroenteritis. This situation is particularly true of underdeveloped areas with poor sanitation, and many endemic areas in this study fit this description. Thus, in identifying cholera endemic tracts, attention can only be paid to the recorded monthly mortality and morbidity statistics of cholera. One cannot, however, ignore other relevant epidemiological information to identify actual endemic foci. Such information has been obtained in this research by personal discussion with the epidemiologists, statisticians, health officials and health workers in the study area, as well as from printed documents and literature available from medical and health journals.

Certain limitations are involved in using areal units based on state's administrative districts for depicting geographic distribution and trends. This kind of macro-level analysis does not actually identify small endemic foci. As noted previously, mortality data have been reported and published for Tamil Nadu, at the state, district and town level (population 30,000 and above); taluk level data can be obtained only with great difficulty from the original returns. Hence, the quantitative assessment of health problems is useful in providing us with only a broad look at the situation. A more exact picture would be possible only with micro-level field surveys and research, which are lacking in the study area.

The Census report states that there are errors involved in the registrations of statistics, because the entries are often made not immediately after a death occurs but just before the returns are due. As previously noted, other errors result from difficulties in distinguishing between various causes of death. Moreover, it notes that "when registration is made compulsory in any area, the statistics for that area generally diminish at first in accuracy". This is because the registering officers believe that when compulsion is introduced, they need record only what is reported to them (p. 16). Perhaps vital statistics could be improved by enforcing the penal provision of the Acts.

The Census document is also critical of the compilation procedures followed by the statistical branch of the Public Health Department, which, in this writer's opinion, is found to be confirmed. For example, when an unusual gap or error appeared in the data collected, there was no way to clarify, for instance, the degree of efficacy of registration areas in the State. The Census states that the existing procedure followed by the Tahsildar is simply to forward the returns of births and deaths to the office of the Director of Public Health, without checking the accuracies of them. If returns were properly reviewed by the Tahsildars, it would have been possible for them to identify those villages which were poor in registration and rectify the situation within a short period of time. Also, no attempt has been made by the statistical division to classify areas into accurate or inaccurate registration categories, nor any information compiled to identify the probable degree of under-registration in different parts of the State. The report critically notes that the office of the Director of Public Health has functioned as a collecting agency and has not taken steps to assure collection of accurate data (p. 83). This report considers that even though it is not done, it is always possible to assure accuracy of data collected by village officers by periodical surveys conducted from time to time. According to this report, that in its own analysis to clarify registration efficiency of areas from available mortality data, that in 1961, out of 103 taluks in Tamil Nadu, only 13 have registration which may be regarded as "better", but no obvious action has been taken to improve the situation (p. 81).

The above observations show that there is a great need to improve the standard of registration systems in terms of routine data collection on vital and health statistics. Improvements in the field coverage as well as accuracy of data are needed. A system of easy storage and retrieval of data from public health records also should be implemented.

PART III

THE GEOGRAPHIC DISTRIBUTION OF CHOLERA IN TAMIL NADU

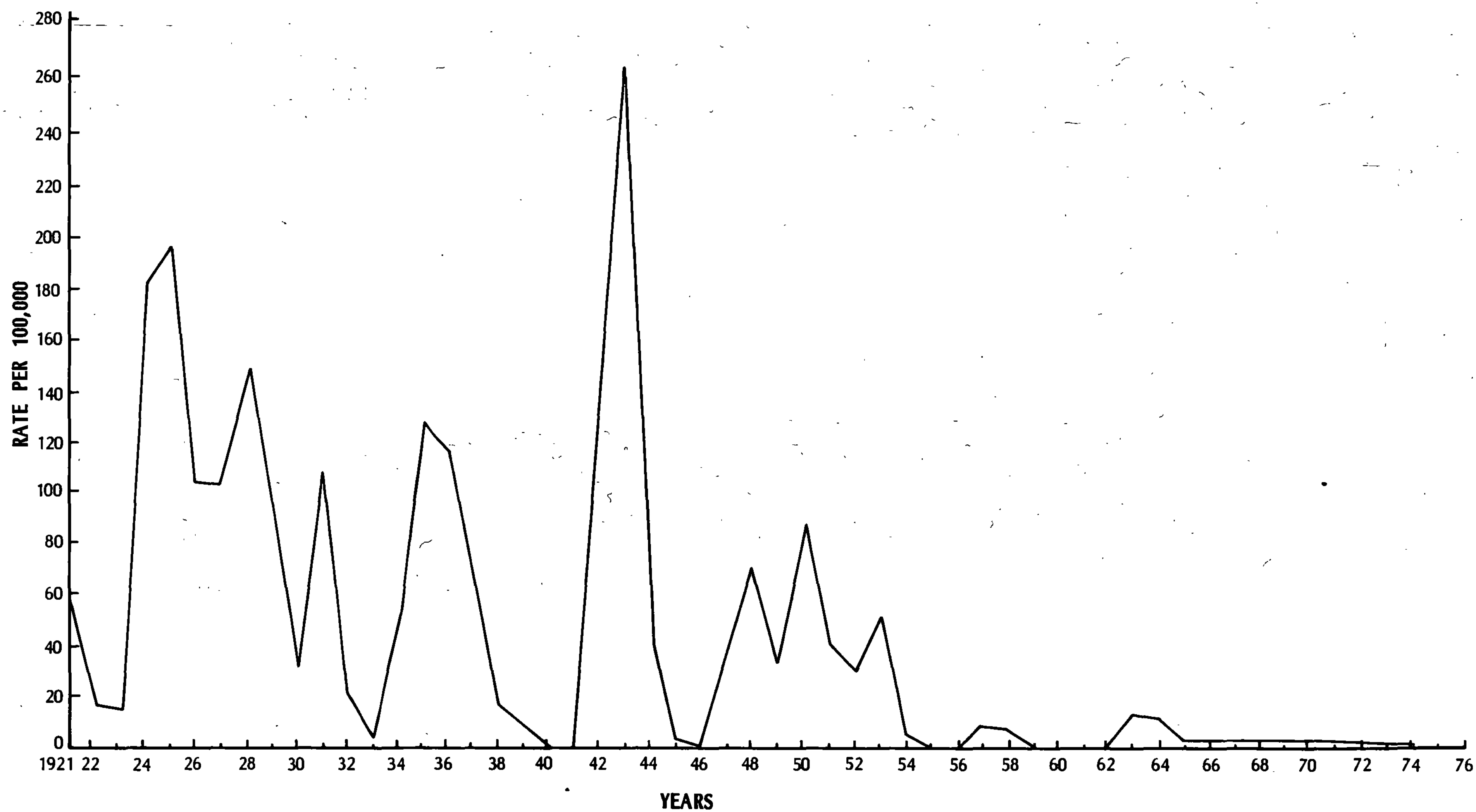
One major objective of this paper is to present an analysis of the incidence and distribution patterns of cholera since the 1960's in various districts of Tamil Nadu. Statistical data are presented in this section through the use of charts and maps. A study of the distribution of disease in a population helps to determine the nature and the amount of preventive, diagnostic and treatment services necessary and the locations required.

Trends in Death Rate from Cholera in Tamil Nadu, 1921-1974

Figure 1 presents the general death rate pattern in the State during the period 1921-1974. Although fluctuations are apparent (Table 1), cholera mortality was high prior to 1950. The overall death rate decreased gradually from 1924 to 1933. Two significant peaks observed in 1935 and another in 1943 followed by another smaller peak in 1950. The epidemic in 1943, the highest in this period, claimed 71,156 lives.

Studies of periodicity of cholera outbreaks suggest a six-year cycle in its occurrence in epidemic form (Pollitzer and Swaroop, 1952; Russell and Sundararajan, 1928). Approximately consistent with a small peak in 1950, 26,341 lives were lost, following the epidemic in 1943. Although the number of deaths registered from cholera has decreased further since 1950, the trend has not been continuous. It is clear that the improved health facilities and preventive measures (mainly innoculations) taken

Fig. I DEATH RATES FROM CHOLERA FOR TAMIL NADU, 1921 - 74 (Per 100,000)



SOURCE: Tamil Nadu Public Health Records, Statistical Division, Directorate of Health Services and Family Planning, Government of Tamil Nadu.

TABLE 1

MORTALITY FROM CHOLERA IN TAMIL NADU, 1921-1974

Year	Estimated Mid-Year Population	Cholera Deaths	Death Rate (per 100,000 Population)	Cholera Attacks	Attack Rate (per 100,000 Population)
1921	21,260,853	12,170	57.2	-	-
1922	21,438,964	3,507	16.4	-	-
1923	21,619,078	3,265	15.1	-	-
1924	21,801,266	39,678	182.0	-	-
1925	21,985,556	43,138	196.2	-	-
1926	22,171,964	23,036	103.9	-	-
1927	22,360,552	22,836	102.1	-	-
1928	22,551,476	33,435	148.3	-	-
1929	22,744,704	23,532	103.5	-	-
1930	22,940,013	6,792	29.6	-	-
1931	23,158,151	24,974	107.8	-	-
1932	23,419,450	4,788	20.4	-	-
1933	23,684,028	777	3.3	-	-
1934	23,951,960	11,520	48.1	-	-
1935	24,223,301	31,304	129.2	-	-
1936	24,498,136	28,430	116.0	-	-
1937	24,776,528	17,554	70.9	-	-
1938	25,058,605	3,990	7.2	-	-
1939	25,344,381	1,837	15.9	-	-
1940	25,634,100	112	7.2	-	-
1941	26,945,322	120	0.4	-	-
1942	26,295,986	30,703	116.8	-	-
1943	26,653,219	71,156	267.0	-	-
1944	27,017,281	10,029	37.1	-	-
1945	27,388,440	914	3.3	-	-
1946	28,153,470	172	0.6	-	-
1947	28,548,064	11,217	39.8	-	-
1948	29,837,377	20,254	70.9	-	-
1949	30,231,324	9,409	32.0	-	-

TABLE 1 (continued)

Year	Estimated Mid-Year Population	Cholera Deaths	Death Rate (per 100,000 Population)	Cholera Attacks	Attack Rate (per 100,000 Population)
1950	30,569,545	26,341	88.3	-	-
1951	30,911,994	12,692	42.0	33,613	-
1952	31,258,801	9,081	29.7	29,993	-
1953	31,609,949	16,517	53.4	43,948	-
1954	31,258,801	1,575	5.0	3,917	-
1955	31,609,949	291	0.9	1,140	-
1956	31,965,591	6	0.002	29	-
1957	32,325,837	2,930	9.1	9,150	-
1958	32,690,825	2,312	7.1	6,508	-
1959	33,060,567	206	0.6	460	-
1960	33,435,162	20	0.06	26	-
1961	33,769,000	29	0.085	59	0.17
1962	34,162,000	69	0.201	827	2.14
1963	34,519,000	4,704	13.63	11,412	33.06
1964	34,876,000	3,935	11.28	10,378	29.75
1965	35,233,000	838	2.38	2,916	8.27
1966	35,590,000	681	1.91	2,693	7.56
1967	35,947,000	647	1.79	3,552	9.88
1968	36,304,000	568	1.56	5,980	16.47
1969	36,661,000	632	1.72	5,471	14.92
1970	37,018,000	248	0.67	1,280	3.45
1971	41,448,000	156	0.38	2,385	5.75
1972	42,193,000	197	0.47	3,281	7.77
1973	42,938,000	226	0.52	3,028	7.05
1974	43,683,000	109	0.24	3,586	8.2
1975 (up to May)	44,428,000	37		1,418	

Compiled from: 1. India, Census of India 1961, Vol. IX, Madras: Demography Statistics (Report), Part I-B(i) (Madras: Government of Madras Press, 1965), pp. 131-132.

2. Unpublished records from Statistical Division, Directorate of Public Health and Family Planning Services, Government of Tamil Nadu.

- Data not available.

after the planning period (especially after the first Five Year Plan), have reduced the mortality rate. Although two small peaks were noticed during 1957-58 and 1963-64, they were much lower than those of 1943 and 1950. The epidemic status has progressively declined since 1965. The data clearly indicate effective control over the mortality rate of this disease.

From the table below, it is clear that the overall (1921-1974) frequency of occurence of disease shows some definite pattern:

	Deaths/100,00 population	Number of Years of Occurrence
Below	20 -	30
	20 - 40	6
	40 - 60	4
	60 - 80	2
	80 -100	1
Above	100	11

As the rate of mortality increases, the number of years which occur in each frequency decreases, indicating that high mortality rate is found only in few selected (epidemic) years. However, the phenomenon is clearly disturbed by a very high frequency of 11 years in the category above 100, i.e., about 20 percent of the total years (54) fall into this category. This is mainly due to the high mortality during the epidemic years before 1950.

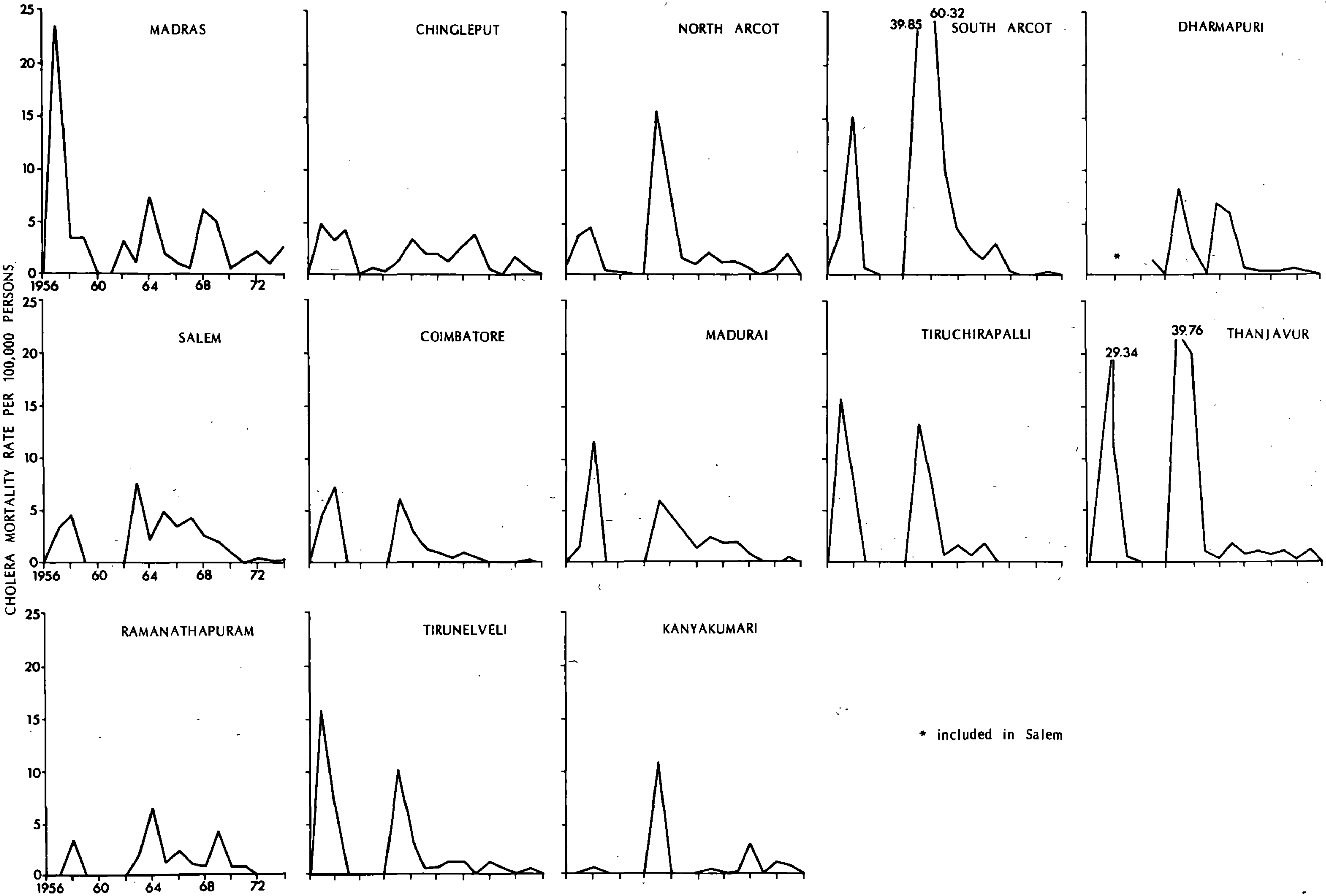
Trends in Mortality Rate by Districts, 1956-1974

The death rate figures for all the districts of Tamil Nadu indicate that there has been a gradual decrease in intensity since 1957 (Figure 2). Interesting patterns are apparent for some of the districts, for instance, 50 percent of the districts indicate a high peak during 1957-58 -- Madras (23.58), Tiruchirapalli (15.86), Thanjavur (29.34), Tirunelveli (15.21); while in the other districts the rate falls below 5.0. It is found, however, that the sharp increase in mortality during 1957 was much less than the average for the period 1951-57. The Annual Health Report of the Public Health Department (1958) states that cholera has been responsible for only 0.3 percent of all deaths in 1957.

A seasonal pattern in incidence was seen, tending to occur in the latter half of the year. The state was completely free from cholera during the first quarter of 1957. In August, 1957, a serious epidemic broke out in Tiruneveli and Madras, gradually declining toward the end of the year. An epidemic was prevalent in Thanjavur and other deltaic districts during November and December, continuing in the first quarter of 1958. The infection was reported to be carried from district to district by the movement of agricultural laborers, and through irrigation canals.

A general decrease in death rates in almost all the districts occurred during 1959-62, so much so that in 1960-61 the state was practically free from cholera. According to the Public Health Report, out of the recorded 20 deaths, 6 occurred in two municipal towns and 14 in rural areas. Large-scale innoculation campaigns conducted during 1956-

Fig. 2 MORTALITY RATE FROM CHOLERA BY DISTRICT, TAMIL NADU 1956-74 (per 100,000)



62 were responsible for this significant decline in incidence. In 1962, although deaths were reported in five districts (Thanjavur, North Arcot, South Arcot, Chingleput and Madras), except Madras (3.05), the rate was found insignificant in all the other districts.

In the latter part of 1963 and the early part of 1964, peaks in death rate were noted in all the districts. The Annual Health Report (Madras, 1965) states that this epidemic reached its peak during the third week in January, involving a large number of villages situated on the river banks, mainly in the districts of South Arcot, Thanjavur, Tiruchirapalli and North Arcot. By the end of February 1964, the incidence was almost under complete control, and from March to October only sporadic cases were reported. The heavy rains in the month of November resulted in an increase of infection once again, raising the death rate during this year in South Arcot (60.32) and Madras (7.30), Ramanathapuram (6.31) and Chingleput (5.84). The district of South Arcot showed a record of a very high death rate (60.32) in 1964, and, in fact, during the entire period of 1956-74. Thanjavur followed, registering a peak during 1963 and 1964 (39.76 and 19.77). During 1964-65 Nilgiris and Kanyakumari were complete free from cholera incidence.

From 1965, the death rate in all the districts declined with some slight undulations observed during 1966-68. For instance, South Arcot (4.5), Salem (4.2) and Dharmapuri (6.69) were conspicuous during the year of 1967. The Annual Health Report noted that the incidence continued to be prevalent during the beginning of 1967, but a decline was noticed after April, followed by an upward trend in November and December, 1967. Higher incidence during January and February was attributable to heavy rains and the beginning of harvest season which attracted a large number of migrant labour. During 1968, cholera was prevalent in epidemic form only in Madras, Madurai, and Chingleput districts, while the districts of Kanyakumari and Nilgiris were free from infection. Madras City reported the largest number of deaths (114) in 1968, and for the year 1969, high death rates were reported from Ramanathapuram (4.02) and Madras (4.91). The epidemic in the Ramanathapuram district, which claimed 110 lives was reported to be due to dry, acute drought conditions and scarcity of food (Health Report, 1970).

For the year 1970, cholera deaths were reported from all districts except the Nilgiris. In order of severity of deaths, the affected areas were: Kanyakumari (31 deaths); Thanjavur (30); North Arcot (27); Madurai (26); and Salem (26). Rates were found to be lower (below unit level) than in previous years. In 1971, cholera was noticeably prevalent in Thanjavur, Ramanathapuram, Madras and Tirunelveli. However, rates were below one unit. In 1972, cholera was noticed in all the districts except the districts of Ramanathapuram and the Nilgiris. In 1974, out of a total of 109 deaths reported in Tamil Nadu (Table 3a), the highest was found in Madras (71), followed by Salem (9), North Arcot (8), Tiruchirapalli (7), and South Arcot (5). Before May, 1975, districts reporting deaths were Madras (13), Tiruchirapalli (11), Madurai (4), Ramanathapuram (4), North Arcot (3), Coimbatore (2), with a total of 37 deaths for Tamil Nadu (Table 3b). Death rates in all the districts have declined below 1 since 1970.

TABLE 2

MEAN DEATH RATE FROM CHOLERA, 1896-1960

DISTRICT	1896-1926	1956-60 Average annual deaths	1956-60 Rate (per lakh of persons)
Madras	91	108	6.59
Chingleput	101	49	2.30
North Arcot	115	51	1.66
South Arcot	188	115	3.87
Salem	132	59	1.60
Coimbatore	139	83	2.41
Nilgiris	---	---	---
Madurai	126	84	2.69
Tiruchirapalli	144	138	4.42
Thanjavur	257	268	8.44
Ramanathapuram	126	18	0.77
Tirunelveli	190	119	4.46
Kanyakumari	---	2	0.21
State		1,094	3.35

Source: India, Census of India 1961, Vol. IX, Madras: Demography and Vital Statistics (Report), p. 170.

Average Annual Death Rate by Districts, 1956-1974

In analysing the spatial pattern of the average annual death rates for the period 1961-74, it is interesting to examine the earliest possible picture of cholera in Tamil Nadu. Table 2 indicates the high death rate was in the Thanjavur district, followed by South Arcot and Tirunelveli. Closer observation reveals a correlation between the occurence of high rate and the important river basins, especially the lower reaches such as the Tambaraparani basin in Tirunelveli district, the Palar river tract in the Chingleput district and the Ponnaiyar river basin in the South Arcot district. These were reported not to be free from cholera during this entire period.

1956-60

Figure 3 shows a different spatial pattern, with concentrations found in several different zones, the endemic tracts of Thanjavur and Madras, in the adjoining two districts of South Arcot and Chingleput, and further south in the Tiruchirapalli and Tirunelveli districts. In this period, the death rate was only one-twentieth of the rate that prevailed half a century before. This reduction is as reported by Health Records, mainly due to a concerned effort to improve the water supply and sanitation, expand the preventive health staff for communicable diseases, and effect of other preventive measures, such as innoculation campaigns, during this period.

1961-65

Exceptionally high death rates were found in South Arcot (22.05) and

(22.05) and Thanjavur (12.21), North Arcot (5.08) and Tiruchirapalli (4.37). Other interior districts and southern regions showed a lower rate (Figure 3).

1966-70

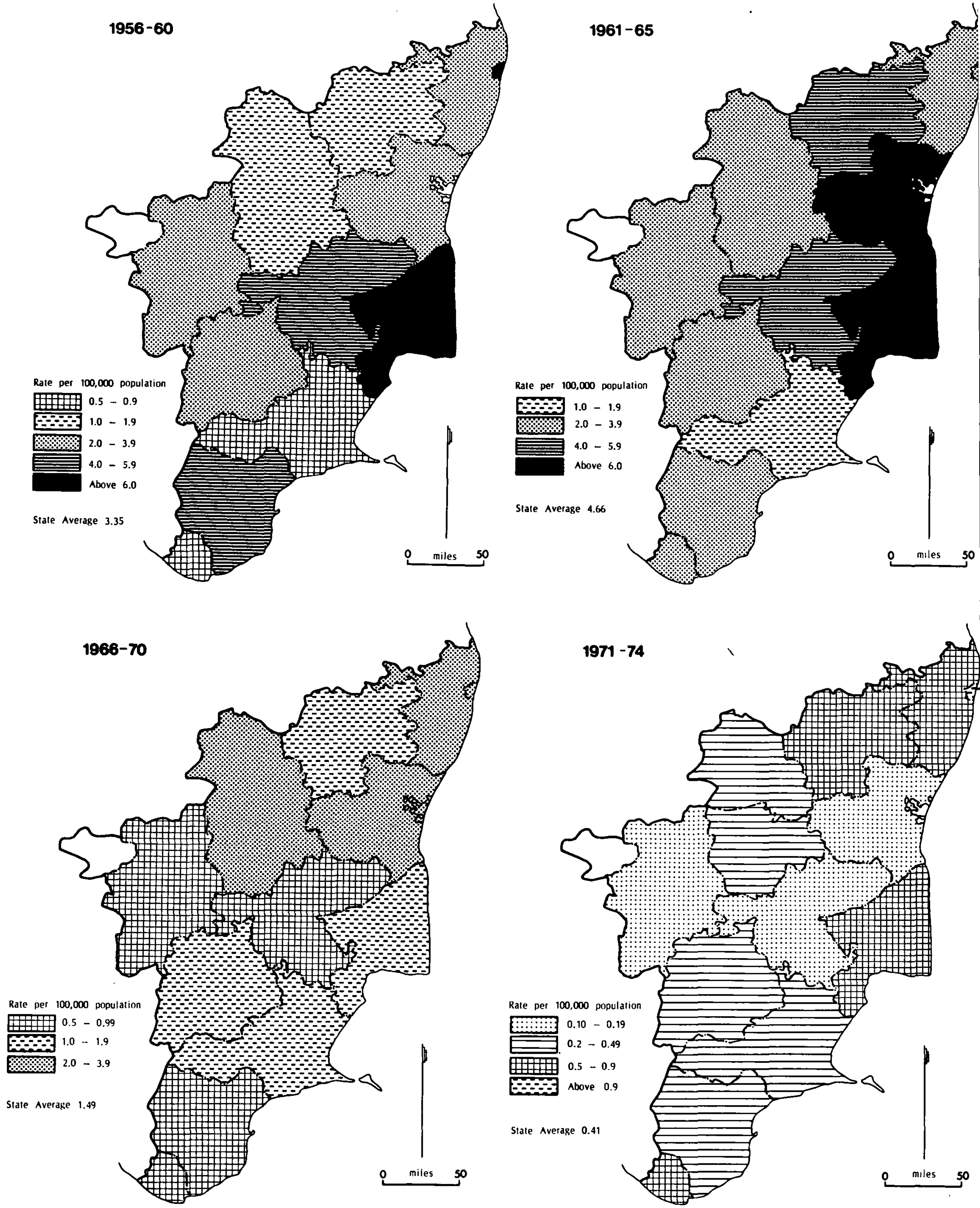
This period in general showed a comparatively lower rate than the previous periods. It did differ from that of the spatial pattern from the previous years (1961-65), in that the concentration seems to have pushed to the north of Tamil Nadu (Figure 3), covering both the interior (Salem and Dharmapuri) and coastal (South Arcot and Chingleput) districts.

1971-74

Madras City appears to be the center of a highly concentrated zone for this period with a rate of more than 1.5. All the other districts show a figure less than 1, North Arcot (0.68), Thanjavur (0.59), Chingleput (0.56), and Kanyakumari (0.51).

Overall patterns indicate that from 1896 to 1965, Madras and Thanjavur were the two districts having a comparatively high average annual death rate (above 5.0) from cholera. Currently (1971-74), all districts entered a low rate, below 1, with the districts of Madras, Chingleput, North Arcot and Thanjavur experiencing relatively medium rates in the range 0.5 - 1.0. One of the reasons given for the lower death rates since 1964 is the introduction of the new El Tor biotype of cholera; mortality from this variety was found to have been low, even though the attack rates have been found to be relatively higher.

Fig.3 AVERAGE ANNUAL CHOLERA DEATH RATE BY DISTRICTS, TAMIL NADU, 1956-74.



Average Annual Attack Rate by Districts, 1961-1974

Average annual attack rates at five year intervals (1961-65, 1966-70, 1971-74) are compared for the various districts of Tamil Nadu (Figure 4). Data for districts were available only from 1961.

1961-65

Figure 4 indicates that the nucleus of attacks was centered around the coastal zones which covers the districts of Madras, South Arcot and Chingleput. Westward and southward in the state the rate decreased. There seemed to be some correlation between the lower reaches of river basins and the higher incidence of cholera.

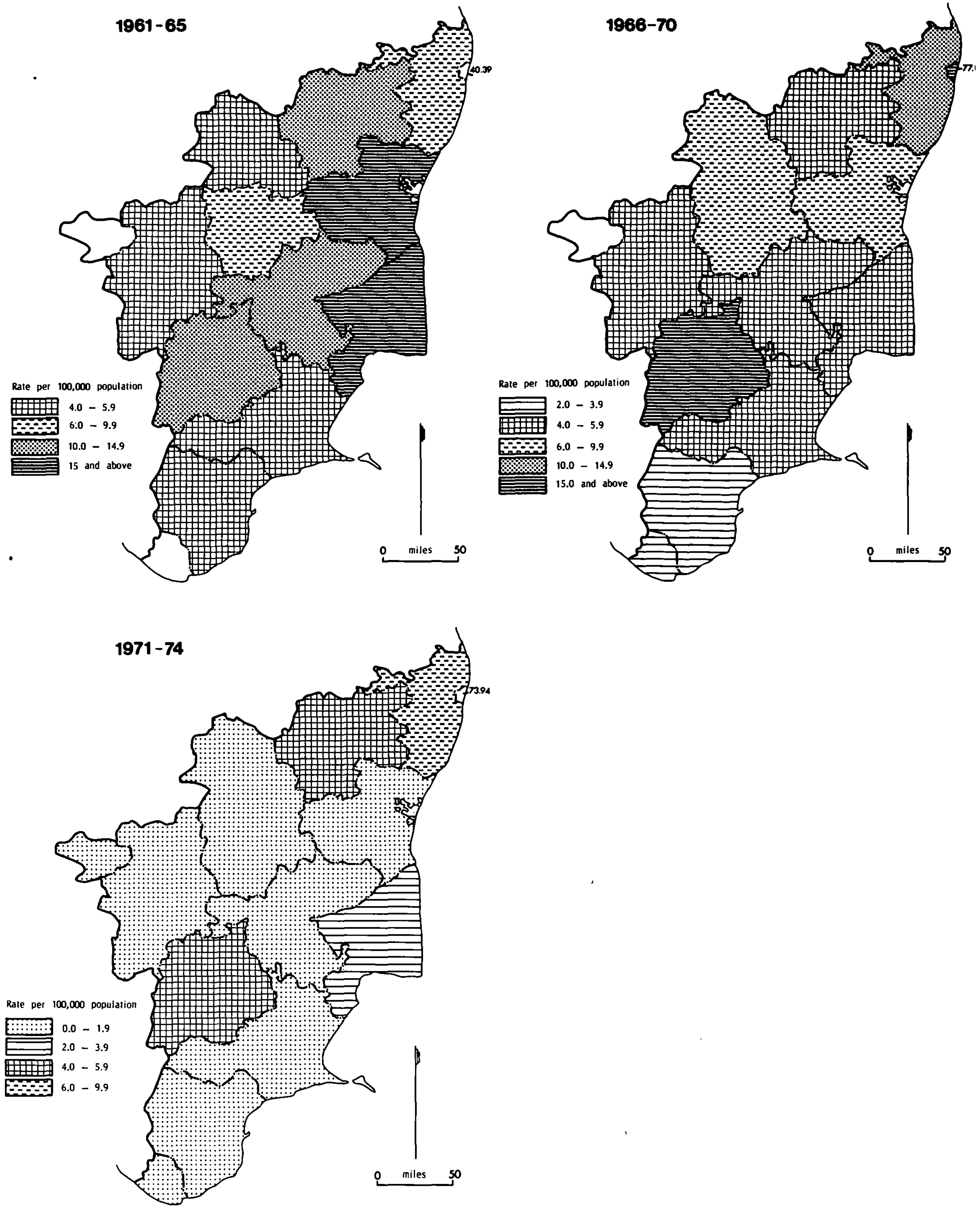
1966-70

The rates were much lower in this period than in the period 1961-65. The area of higher rates had moved inland covering the districts of Madurai, Salem and Dharmapuri, although Madras and the adjoining Chingleput continued to experience high rates.

1971-74

Figure 4, depicting the average annual attack rate for the period 1971-74, indicates that, in general, the rate had declined significantly compared with the previous periods. Madras City and Salem reported very high figures of 2,860 cases and 168 cases respectively, of a total 3,586 cases for the State for the year 1974, and up to May 1975, Madras (893) and Madurai (252 cases) rank high out of a total of 1,418 cases reported

Fig.4 AVERAGE ANNUAL CHOLERA ATTACK RATE BY DISTRICTS, TAMIL NADU, 1961-74.



for Tamil Nadu as a whole. The average annual rate for this period being higher in Madras (73.94) followed by Chingleput (9.64), Madurai (5.76), North Arcot (4.99), Thanjavur (2.41) and Salem (2.18). The concentration seems to be in the northern part of the State. In the south and the interior, except for Madurai, districts were less susceptible to attack.

The overall analysis indicates that the Madras district is found to be in the forefront with a very high annual attack rate (more than 30). Districts like Madurai and South Arcot, fluctuate in a range between 5 and 30, indicating that these districts were moderately susceptible. During the period 1961-65, only about 15 percent of the total districts (14) were found in the group below 5, the remainder were above this rate. The percentage figures have increased gradually (1966-70, 46 percent of the districts below 5; 1971-74, 50 percent below 5); indicating that more and more districts have become free from high rates of cholera attacks.

Through May, 1975, it is noticed (Table 3b) that the largest number of cholera cases were reported from Madras City (893), Madurai (252), Tiruchirapalli (93), Dharmapuri (41), South Arcot (61), Ramanathapuram (10) of the total of 1,418 attacks reported for the State as a whole. This may be partially due to acute drought conditions prevailing in some districts, failure of monsoons, and scarcity of water in recent months.

TABLE 3a

MONTHLY INCIDENCE OF CHOLERA BY DISTRICTS, TAMIL NADU, 1974

A = Notified Attacks
D = Registered Deaths

Districts	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Total	
	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
1. Madras City	330	6	203	3	253	7	383	11	352	12	203	3	241	2	469	17	155	2	110	3	113	3	48	2	2,860	71
2. Chingleput	-		2	0	1	0	1	0	2	0	3	0	2	0	2	0	1	0	-		-		-		14	0
3. North Arcot	-		1	1	8	0	18	2	8	2	11	0	25	1	13	0	35	0	8	0	4	1	3	1	134	8
4. South Arcot	15	4	6	0	3	0	-		-		-		1	0	3	0	2	0	7	1	12	0	-		49	5
5. Dharmapuri	-		-		-		3	1	1	0	-		4	0	4	0	1	0	-		-		-		13	1
6. Salem	8	2	18	0	33	1	23	3	-		18	0	12	0	26	0	3	1	11	1	9	0	7	1	168	9
7. Coimbatore	11	2	17	0	5	0	8	0	3	0	1	0	6	0	9	0	28	1	4	0	12	0	3	0	107	3
8. Nilgiris	-		-		-		-		-		-		-		-		-		-		6	0	1	0	7	0
9. Madurai	3	0	4	0	5	0	-		15	0	-		3	0	-		5	0	2	0	8	0	1	0	46	0
10. Tiruchirapalli	14	0	18	0	-		8	3	4	2	2	0	-		-		13	1	4	0	4	1	53	0	120	7
11. Thanjavur	4	1	10	0	-		-		-		-		-		1	0	-		-		-		-		15	1
12. Ramanathapuram	-		5	0	-		-		6	0	1	0	-		-		1	0	3	1	20	0	6	0	42	1
13. Tirunelveli	-		-		5	0	-		-		-		-		-		-		-		1	0	2	2	8	2
14. Kanyakumari	-		-		-		-		-		-		-		-		1	1	2	0	-		-		3	1
	385	15	284	4	313	8	444	20	391	16	239	3	294	3	527	17	245	6	151	6	189	5	124	6	3,586	109

Source: Unpublished Data, Statistical Division, (Epidemiology Section), Directorate of Public Health Services and Family Planning, Government of Tamil Nadu.

TABLE 3b

MONTHLY INDIDENCE OF CHOLERA BY DISTRICTS, TAMIL NADU, 1975

A = Notified Attacks
D = Registered Deaths

	District	January A	January D	February A	February D	March A	March D	April A	April D	May A	May D	Total A	Total D
1.	Madras City	104	1	233	5	300	3	169	4	97	0	893	13
2.	Chingleput	-		-		-		-		3	0	3	0
3.	North Arcot	1	0	-		7	3	1	0	4	0	13	3
4.	South Arcot	3	0	-		32	0	6	0	-		41	0
5.	Dharmapuri	-		1	0	-		-		-		1	0
6.	Salem	8	0	10	0	3	0	21	0	5	0	47	0
7.	Coimbatore	3	1	6	0	1	1	-		-		10	2
8.	Nilgiris	-		-		-		-		-		-	
9.	Madurai	4	0	42	1	76	2	72	0	58	1	252	4
10.	Tiruchirapalli	22	0	23	1	34	10	14	0	-		93	11
11.	Thanjavur	21	0	5	0	-		-		-		26	0
12.	Ramanathapuram	7	2	2	0	-		11	1	4	1	24	4
13.	Tirunelveli	12	0	3	0	-		-		-		15	0
14.	Kanyakumari	-		-		-		-		-		-	
	Total	185	4	315	7	453	19	294	5	171	2	1,418	37

Source: Statistical Division, Directorate of Public Health Services and Family Planning, Government of Tamil Nadu.

Number of Registered Deaths Due to Cholera by Districts, 1901-1974

Table 4a indicates that up to 1950, Thanjavur and South Arcot districts had the highest number of registered deaths computed at five year intervals. Until 1930, Thanjavur scored the highest rank except in 1916-20, then, during 1951-55, Kanyakumari took over the top rank, the exact reason is still unclear. For the period 1971-74, Madras City District has taken the first spot, followed by North Arcot. Strangely, endemic South Arcot is nowhere in the picture. Similarly, districts like Tirunelveli and Tiruchirapalli, which were scoring second and third rank during 1956-60, do not find a place in the ranking column for 1971-74. Madurai appears to be the only interior district in the ranking column. Another striking feature in 1971-74 is that all the first five ranking districts show very low figures with regard to registered deaths as compared with earlier periods.

Total Number of Notified Cases of Cholera by Districts, 1961-1974

Table 4b presents the districts ranked at five-year intervals according to the notified attacks of cholera since 1961. A somewhat different picture emerges when compared with Table 4a. In the epidemic year, 1963, the districts of Thanjavur, South Arcot, North Arcot, Madras and Madurai reported higher cases of attacks. Between 1967 and 1971, Madras and Madurai continued to register large numbers of cases and occupy the first and second ranks. Endemic South Arcot, having disappeared from the scene after 1966, later appeared in the fifth column in 1973. The decline in incidence in this district may have been due to the

TABLE 4(a)

TOTAL NUMBER OF REGISTERED DEATHS DUE TO CHOLERA BY DISTRICTS, TAMIL NADU, 1911-1974
(Ranking The Districts According To Total Cholera Deaths Reported)

	District		(Rank)		
Year	1	2	3	4	5
1911-1915	Thanjavur (33,482)	South Arcot (19,854)	Madurai (13,868)	Tiruchirapalli (13,464)	North Arcot (13,409)
1916-1920	South Arcot (17,353)	Salem (17,292)	Madurai (17,284)	Tirunelveli (16,148)	Thanjavur (15,918)
1921-1925	Thanjavur (17,094)	Madurai (14,599)	South Arcot (12,127)	Tirunelveli (11,697)	Coimbatore (11,776)
1926-1930	Thanjavur (28,000)	South Arcot (14,720)	Tirunelveli (12,358)	Tiruchirapalli (10,531)	Madurai (7,335)
1931-1935	South Arcot (18,539)	Thanjavur (8,949)	North Arcot (8,710)	Madurai (6,400)	Tiruchirapalli (5,686)
1936-1940	Thanjavur (10,024)	South Arcot (6,589)	Coimbatore (5,930)	Madurai (5,686)	Tirunelveli (5,011)
1941-1945	South Arcot (17,725)	North Arcot (15,631)	Thanjavur (14,926)	Tirunelveli (13,245)	Coimbatore (11,505)
1946-1950	Thanjavur (12,445)	Madurai (9,359)	South Arcot (9,065)	Tiruchirapalli (6,571)	Tirunelveli (6,057)
1951-1955	Kanyakumari (5,983)	Thanjavur (5,004)	South Arcot (4,760)	Tiruchirapalli (4,714)	Madurai (4,058)
1956-1960	Thanjavur (1,341)	Tiruchirapalli (692)	Tirunelveli (597)	South Arcot (576)	Madras (541)
1961-1965	South Arcot (3,452)	Thanjavur (2,023)	North Arcot (818)	Tiruchirapalli (713)	Madurai (441)
1966-1970	South Arcot (410)	Salem (340)	Madurai (300)	Madras (246)	Chingleput (245)
1971-1974	Madras (183)	North Arcot (107)	Thanjavur (93)	Chingleput (68)	Madurai (34)

Source: Compiled from India, Census of India, 1961, Vol. IX, Madras: Demography and Vital Statistics (Report), pp. 98-101.
Unpublished Public Health Records, Statistical Division, Directorate of Public Health Service and Family

TABLE 4(b)

TOTAL NUMBER OF NOTIFIED CASES OF CHOLERA BY DISTRICTS, TAMIL NADU, 1961-1974

Districts (Rank)

Year	1	2	3	4	5
1961-1965	South Arcot (6,991)	Thanjavur (4,426)	Madras (3,678)	North Arcot (2,126)	Madurai (1,997)
1966-1970	Madras (7,571)	Madurai (2,646)	Chingleput (1,493)	Salem (1,303)	South Arcot (1,071)
1971-1974	Madras (7,632)	Chingleput (1,160)	Madurai (926)	North Arcot (778)	Thanjavur (379)

Source: Unpublished Public Health Records, Statistical Division, Directorate of Public Health Services and Family Planning, Government of Tamil Nadu.

preventive measures that were introduced, while the later increase might have been due to the reappearance of the epidemic cycle after seven years. Thanjavur continued to be endemic; it has occupied the third position more or less since 1967. Since 1974 and early 1975 interior districts of Salem, North Arcot, Tiruchirapalli and Coimbatore have been reporting cases of cholera (Tables 3a and 3b) for which explanations are not available.

Notified Cases and Registered Deaths Due to Cholera by Districts, 1951-1974

It is found in Table 5a that during the last 23 years, there were on an average of 7,900 cases per annum of cholera, of which deaths numbered 2,798 per annum. The average case fatality rate was 35 percent of the notified cases. There have been fluctuations in the number of attacks as well as deaths, and in the decennium under consideration, the maximum was recorded in 1953 (Table 5a). There was a gradual decrease in the percentage figures from 1953 to the present, but a significant increase during the epidemic years 1958 to 1967. For the last three years, there have been fewer deaths (less than 7.5 percent) than attacks.

In general, in almost all of the districts of Tamil Nadu (Table 5b), the percentage of deaths over attacks has been declining from 1961-65 to 1971-74. However, Tiruchirapalli, Tirunelveli, Kanyakumari and Thanjavur districts do show consistently higher percentage figures than the other districts. The reason is not known. Deaths are reported more accurately, however, than attacks.

TABLE 5a

NOTIFIED CASES AND DEATHS DUE TO CHOLERA IN TAMIL NADU, 1951-1974

Year	Notified Cases	Deaths	Percentage (Deaths per 100 cases)
1951	33,613	12,552	37.3
1952	29,993	9,081	30.3
1953	43,948	22,445	51.1
1954	3,917	1,592	40.6
1955	1,140	291	25.5
1956	29	6	20.7
1957	9,150	2,930	32.0
1958	6,508	2,312	35.5
1959	460	206	44.8
1960	26	20	76.9
1961	59	29	49.1
1962	827	69	8.3
1963	11,412	4,704	41.2
1964	10,378	3,935	37.9
1965	2,916	838	28.7
1966	2,693	681	25.2
1967	3,552	647	18.2
1968	5,980	568	9.4
1969	5,471	632	11.5
1970	1,280	248	19.3
1971	2,385	156	6.5
1972	3,281	197	6.0
1973	3,028	226	7.4
1974	3,586	109	3.03

Compiled from: Public Health Records, Statistical Division, Directorate of Public Health Services and Family Planning, Government of Tamil Nadu.

TABLE 5(b)

NOTIFIED CASES AND DEATHS DUE TO CHOLERA BY DISTRICTS, TAMIL NADU, 1961-1974

	Districts	1961-1965 Total Cases	1961-1965 Total Deaths	1961-1965 Deaths Per 100 Cases	1966-1970 Total Cases	1966-1970 Total Deaths	1966-1970 Deaths Per 100 Cases	1971-1974 Total Cases	1971-1974 Total Deaths	1971-1974 Deaths Per 100 Cases
1.	Madras	3,678	245	6.6	7,571	246	3.2	7,632	183	2.39
2.	Chingleput	832	249	29.9	1,493	245	16.4	1,160	68	5.86
3.	North Arcot	2,126	818	38.4	738	215	29.1	778	107	13.75
4.	South Arcot	6,991	3,452	49.3	1,071	410	38.2	195	18	9.23
5.	Dharmapuri	392	175	44.6	524	194	37.0	116	21	18.10
6.	Salem	863	363	42.0	1,303	340	26.0	273	31	11.35
7.	Coimbatore	868	370	42.6	848	119	14.0	217	20	9.21
8.	Nilgiris	-	-	-	-	-	-	7	-	-
9.	Madurai	1,999	441	22.0	2,646	300	11.3	920	34	3.67
10.	Tiruchirapalli	1,782	713	40.0	800	152	19.0	211	28	13.27
11.	Thanjavur	4,423	2,023	45.7	769	175	22.7	379	93	24.53
12.	Ramanathapuram	606	240	39.6	719	239	33.2	159	31	19.49
13.	Tirunelveli	755	376	49.8	369	104	28.1	146	28	19.17
14.	Kanyakumari	269	108	40.1	125	37	29.6	81	26	32.09
	State Total	25,585	9,573	37.8	18,976	2,776	14.6	12,284	688	5.60

Compiled from: Public Health Records, Statistics Division, Directorate of Public Health Services and Family Planning, Government of Tamil Nadu.

1961-65

Madras City registered a low fatality rate (Table 5b), while endemic South Arcot, Tiruchirapalli, Thanjavur, Dharmapuri and Tirunelveli registered a very high figure, due perhaps to the backwardness here with respect to medical facilities for cholera control. In fact, more than 70 percent of the districts (10) of Tamil Nadu registered above the State average of 37.8 percent during this period.

1966-70

Though the fatality rate has delined during this period, South Arcot still occupied the top position (38.2) followed by two new entrants, Dharmapuri and Ramanathapuram, with a fatality rate of 37.0 and 33.1 percent respectively. The State average was low compared to previous years, yet more than 70 percent of the districts are found to be above this figure. No doubt the overall death rates have declined considerably during this period. It is worth noting that the number of cases reported in Madras during this period was double that of 1961-65, (perhaps due to improved registration systems), and the percentage of deaths over attacks is very low (3.2), obviously indicating better health care facilities in the corporate city.

1971-74

Although the average figure for the State is low (5.6) in this period, there are ten districts well above the State average (Table 5b). The reason for Kanya kumari occupying the first place is not

TABLE 5(c)

CASE FATALITY RATE BY DISTRICTS, TAMIL NADU, 1961-1974

(Deaths Per 100 Cases)

	Rank				
Year	1	2	3	4	5
1961-1965	Tirunelveli (50)	South Arcot (49.3)	Thanjavur (45.7)	Dharmapuri (44)	Salem (42)
1966-1970	South Arcot (38.2)	Dharmapuri (37)	Ramanathapuram (33.1)	North Arcot (29.6)	Kanyakumari (29.6)
1971-1974	Kanyakumari (32.09)	Thanjavur (24.5)	Ramanathapuram (19.49)	Tirunelveli (19.17)	Dharmapuri (18.10)

Compiled by Author from Table 5(b).

known (Table 5c), when, in the past, this district has registered consistently the lowest number of cases. The concentration appeared to be centered around the endemic tracts of Thanjavur and Ramanathapuram districts. The northwest extension zone runs up the Cauvery Valley. The Madras, Chingleput and Madurai districts have low fatality rates despite a largenumber of cases, 7,632, 1,160 and 920 respectively, reported in the State (Table 5b).

Seasonal Incidence of Deaths and Attacks Due to Cholera by Districts, (1956-1974)

It is well known that cholera is a disease which is very much influenced by geographic and climatic factors. Several studies (Park, 1942; Rogers, 1928; Russell and Sundararajan, 1928) have shown that rainfall, humidity and temperature have a close connection with the prevalence of cholera. Certain seasonal conditions are definitely more favourable for the development and transmission of cholera than others. Rainfall is found to have closest connection to incidence, for example, in many areas cholera grows to epidemic proportions during or soon after the rain season. Earlier studies by Russell (1928) and Hesterlow (1929) indicated that districts of Tamil Nadu can be mapped into areas of cholera prevalence in certain seasons of the year. They showed that cholera followed monsoons with great regularity. Four climatic seasons are recognized in the State: (1) the hot, dry period from mid-February to the end of May; (2) the period of the advancing monsoon with a hot, humid season, June to August (the period of south-west monsoon rains fall in the second half of June); (3) the rainy period of retreating monsoon, mid-October to mid-December; (4) post monsoon, the cool, dry period from mid-December to mid-February. The central districts of Tamil Nadu, consisting of Salem, Tiruchirapalli, Coimbatore, Madurai, and Ramanathapuram, experience rainfall from both monsoons; the main rainfall season, however, is from the retreating north-east monsoon. The south-west monsoon prevails mainly in Kanyakumari, Tirunelveli and Nilgiris districts. The northern coastal districts of Thanjavur, South Arcot, Chingleput, Madras and North Arcot receive their annual rainfall from the north-east monsoon.

Looking at Figures 5 and 6, the major peak of cholera incidence is seen to occur in Tamil Nadu as a whole, with the arrival of the north-east monsoon during November and December. January and February, considered the post-monsoon cool, dry season, provide favorable conditions for the persistence of incidence in the State following the monsoon rains. During 1971-74, the total attacks due to cholera, though less in intensity, seem to be somewhat evenly distributed over all months with two small peaks, one occurring in the period including October, November, December, and January, and the other in the summer months of June and July (Figure 6).

The major occurrences of cholera in different districts follow the chief monsoons to some extent. It was noted, however, that when dry conditions are most severe, cholera epidemics are also liable to occur due to the use of contaminated and unsafe water, safe supplies having dried up. Cholera decreases as the water supply improves with the rains.

Fig. 5 SEASONAL INCIDENCE OF DEATHS DUE TO CHOLERA, TAMIL NADU, 1956 - 74. (monthly percentage of deaths)

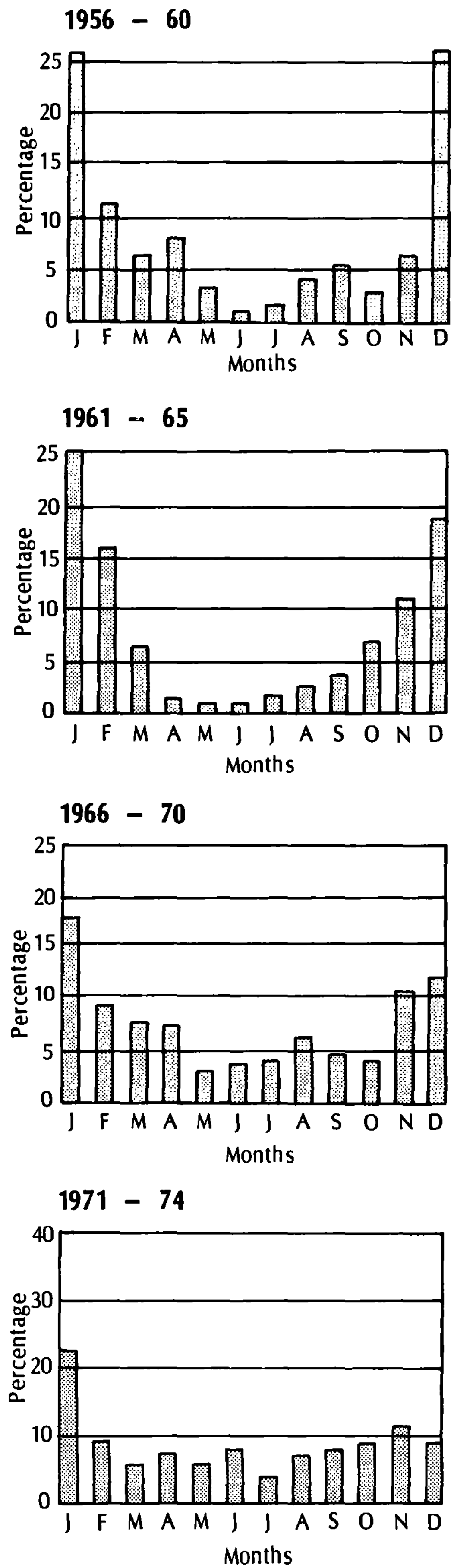
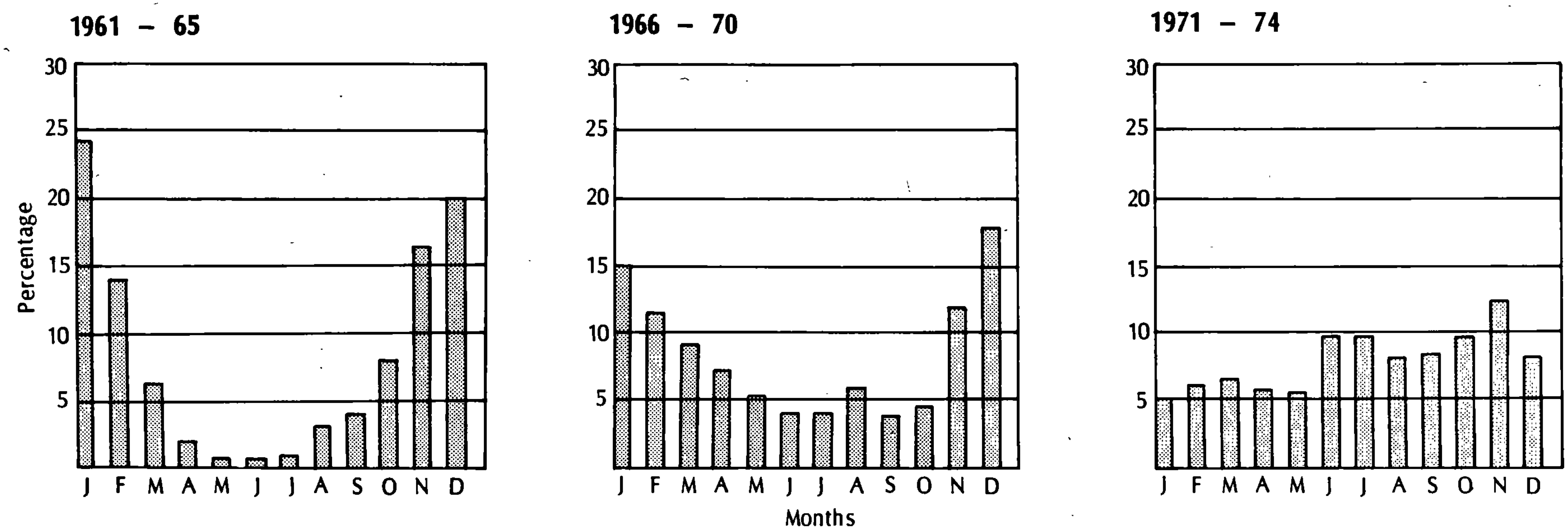


Fig.6 SEASONAL INCIDENCE OF ATTACKS DUE TO CHOLERA, TAMIL NADU, 1961-74. (monthly percentage of attacks)



The total attacks and deaths (in percent) are calculated for each month for every district of Tamil Nadu at the five-year intervals of 1961-65, 1966-70 and 1971-74. Only those percentage figures which are above 10 percent are plotted in Figures 7 and 8 respectively. The main objective of this chart is to visualize the clustering pattern of frequent occurrence of deaths and attacks during the said periods in different districts in different seasons. A glance at the chart indicates that there are two elongated clusters during the post-monsoon (cool) period, viz. December-January-February in case of deaths (Figure 7) and November to February in case of attacks (Figure 8). Almost all districts of Tamil Nadu fall in this group, indicating that the incidence of cholera is more pronounced during the cool, dry season. For a few districts like Tirunelveli and Kanyakumari, the incidence is found to be noticeable during the retreating monsoon period (October - December).

The next important season, but less significant, in which one sees the incidence and deaths due to cholera is the hot, dry season (March to April) when water supplies are at their lowest and large numbers of fairs and festivals occur in the State. Huge floating populations are attracted to the centers, where transmission of infection takes place easily as a result of the limited water supply and resulting contamination by carriers. Interior districts like Dharmapuri, Salem, and Madurai also experience noticeable incidence during this season.

In almost all the districts of the State, the highest percentage of deaths and attacks occur during the period between December and February. It appears then that there is some correlation between the incidence of

Fig. 7

SEASONAL INCIDENCE OF DEATHS DUE TO CHOLERA BY DISTRICTS, TAMIL NADU, 1956-60, 1961-65, 1966-70, 1971-74. (Monthly percentage of deaths 10% and over)

	MAD	CHIN	N.A.	S.A.	DHAR	SALE	COIMB	NILG	MADU	TIRU	THANJ	RAMN	TIRUN	KANY	Season
JAN	◆■	◆●■▲	◆●■▲	◆●■▲	●▲	◆●■▲	◆■▲		◆●■▲	◆●■	◆●▲	◆●	◆●■▲	◆	Post Monsoon Cool Season
FEB		●▲	◆■	◆■	■	◆●■▲	◆●■▲		◆●	●■▲	●■▲	◆●		◆	
MAR			◆●■▲	◆●▲		■			◆		■	●▲			Dry, Hot Season
APRIL		■		▲	■▲	◆■▲			■	◆■▲		▲			
MAY					■						▲		■		
JUNE		▲							▲			▲			Advancing Monsoon Season. Humid, Hot.
JULY					■					●		■▲			
AUG	◆		▲			▲							◆●	◆■	
SEPT	◆▲	◆	▲				▲		▲		●	■	◆	◆●▲	Retreating Monsoon Season
OCT	●▲					●	■		●		●		▲	●▲	
NOV	◆●■▲	◆■	◆●		●	●	●■			●■▲	●	■	●■	◆●■▲	
DEC	●■	◆●■	◆●■▲	●■▲	●■▲	◆●	◆●		●	◆●▲	◆●	◆●■	▲	◆▲	Post Monsoon Cool Season

LEGEND

◆ 1956–60
● 1961–65
■ 1966–70
▲ 1971–73

Fig. 8

SEASONAL INCIDENCE OF ATTACKS DUE TO CHOLERA BY DISTRICTS, TAMIL NADU, 1961-65, 1966-70, 1971-74. (Monthly percentage of attacks 10% and over)

Month	MAD	CHIN	N.A.	S.A.	DHAR	SALE	COIMB	NILG	MADU	TIRU	THANJ	RAMN	TIRUN	KANY	Season
JAN	■	●■	●■▲	●■	●▲	●■	●■▲		●■▲	●	●▲	●	●■▲		Post Monsoon Cool Season
FEB		●		●■	■	●■▲	●■▲		●	●■▲	●■▲	●			
MAR				▲		■▲			▲	■	■	▲			Dry, Hot Season
APRIL		■			■▲	▲			■▲			■▲	■		
MAY					■				▲				■		
JUNE		▲										■▲			Advancing Monsoon Season. Humid, Hot.
JULY	▲	▲								●		■▲			
AUG	▲		■			▲							●	■	
SEPT			▲				■▲			▲	●			●▲	Retreating Monsoon Season
OCT	▲			▲	▲	●	■		●		●		▲	●▲	
NOV	●■▲	■	●		●■	●	●▲			●■	●	■▲	●■▲		
DEC	●■	●■	●	●■	●■	●▲	●		●■	●▲	●	■	▲	▲	Post Monsoon Cool Season

LEGEND

● 1961–65

■ 1966–70

▲ 1971 – 74

MAD – Madras
CHIN – Chingleput
N. A. – North Arcot
S. A. – South Arcot
DHAR – Dharmapuri
SALE – Salem
COIMB – Coimbatore
NILG – Nilgiris
MAD – Madurai
TIRU – Tiruchirapalli
THANJ – Thanjavur
RAMN – Ramanathapuram
TIRUN – Tirunelveli
KANY – Kanyakumari

cholera and the cool season. The peak attacks occurred in the months of April (527) and August (444), followed by 385 cases in January, and 313 cases reported for March. Districts of North Arcot and Salem experienced peak incidence in the south-west monsoon period (June-July-August). However, the data compiled for some districts of Tamil Nadu during the years 1971-74, point a different picture, of a fairly even distribution in incidence throughout all the months of the year (Table 3b). This change in pattern needs some explanation. It was unclear what factors other than rainfall contribute to this deviation of a somewhat even distribution from traditional seasonal patterns of incidence. Adverse economic conditions, the general failure of rains in the 1973-74 period, evaporating water supplies, the resultant water scarcity, and food shortages all over the State may account for this somewhat even distribution of incidence throughout the year (1974). Previous to 1973, only sporadic cases were reported between March and October. Now the incidence appears to be equally distributed over all seasons.

Level of Persistence, 1961-1974

Endemic areas are likely to be found in the districts where cholera incidence persists from month to month. It is expected that the longer the periods without cholera cases or deaths in a district, the less likely it is to contain endemic foci. The present tables (6a and 6b) are compiled from monthly figures of cholera deaths (1956-74) and attacks (1961-74) available from public health records in the Public Health

Department. There are periods of varying duration in which no cases or deaths were recorded. For each district, total monthly cholera attacks and deaths were taken at five-year intervals as well as for the entire period of 1961-1974. The total number of months in which no deaths or cases were recorded is shown as the percentage of total months (60) for the five-year period considered, e.g., 1961-1965 = 5 years x 12 months = 60 months. The names of districts in which the maximum (100 percent) and minimum number of months free from cholera incidence were grouped accordingly in Tables 6a and 6b. This classification affords another method of determining the relative significance of different districts with regard to their endemicity as measured by the persistence level.

1956-60

Madurai, Ramanathapuram, Salem and North Arcot had the highest percentage (above 80) of months free from cholera deaths. Persistence is of a noticeable level in Coimbatore (60.4), South Arcot (69.4) and Thanjavur (69.4).

1961-65

The persistence level was found to be significant in North Arcot (46.6), followed by South Arcot (61.6) and Chingleput (68.3). Districts with months free from attacks closely follow this pattern, but with slightly higher figures, except for Chingleput (58.3) and North Arcot (63.3) (Table 6a). The interior districts exhibited a higher percentage of freedom from attacks than the northern coastal districts. The Nilgiris and Kanyakumari continued to enjoy a higher percentage of freedom from cholera incidence than all the other districts for the entire period studied. North Arcot exhibited a high frequency of incidence in different months during this period.

1966-70

During this period the persistence level is significant in terms of both attacks and deaths in all the districts of Tamil Nadu. Madurai exhibited the lowest number of free months (8.3 percent for deaths) and (1.6 percent for attacks), followed by Salem, Madras, Tiruchirapalli, Chingleput, North Arcot and Ramanathapuram which showed high persistence levels in the 40-50 percent range (Tables 6a and 6b). This period appears to have the lowest percentage of cholera-free months recorded in any district in any period considered. The Madras district, which experienced a high percentage of cholera-free months during the earlier periods, has remarkably come down (36.6 percent death-free months) in 1966-70, again reporting frequent incidence of cases and deaths.

1971-74

A change in overall pattern is noticed with regard to the distribution of percentage figures. Death-free months were fairly high for most of the districts except Madras (22.9), North Arcot (56.2), and Salem (68.7). However, in the case of attack-free months, all districts fluctuated, with a higher frequency of attacks occurring in Madras (10.4 percent), Madurai (2.0), North Arcot (35.4), Salem (45.8), Coimbatore (45.8), Dharmapuri (52.0) and Chingleput (50.0). Ramanathapuram and endemic South Arcot, however, enjoyed a higher proportion of freedom from cholera incidence.

1961-74

The overall pattern of death-free months observed for the entire

TABLE 6 a

CHOLERA PERSISTENCE LEVEL BY DISTRICTS, TAMIL NADU, 1961-1974

Percentage of months free from cholera deaths to total months	1961-1965 (Total number of months = 60)	1966-1970 (Total number of months = 60)	1971-1974 (Total number of months = 48)	1961-1974 (Total number of months = 168)
90 - 100	Nilgiris(100.0) Kanyakumari	Nilgiris Kanyakumari	Nilgiris	Nilgiris Kanyakumari
80 - 90	Dharmapuri Coimbatore Salem Tirunelveli	-	Kanyakumari South Arcot Coimbatore Ramanathapuram Chingleput Tirunelveli	-
70 - 80	Madurai Tiruchirapalli Ramanathapuram Madras Thanjavur	Coimbatore	Tiruchirapalli Thanjavur Dharmapuri Madurai	Coimbatore Tirunelveli Dharmapuri
60 - 70	Chingleput	-	Salem	Thanjavur Ramanathapuram Tiruchirapalli South Arcot Chingleput
50 - 60	-	Tirunelveli Thanjavur Dharmapuri South Arcot	North Arcot	Salem Madurai
40 - 50	North Arcot	North Arcot Tiruchirapalli Ramanathapuram Chingleput	-	North Arcot Madras
30 - 40	-	Madras	-	-
20 - 30	-	Salem	Madras	-
10 - 20	-	-	-	-
0 - 10	-	Madurai	-	-

Compiled by the author from unpublished Public Health records.

TABLE 6 b

CHOLERA PERSISTENCE LEVEL BY DISTRICTS, TAMIL NADU, 1961-1974

Percentage of months free from cholera attacks to total months	1961-1965 (Total number of months = 60)	1966-1970 (Total number of months = 60)	1971-1974 (Total number of months = 48)	1961-1974 (Total number of months = 168)
90 - 100	Nilgiris (100) Kanyakumari	Nilgiris	Nilgiris	Nilgiris
80 - 90	Dharmapuri Salem Coimbatore Tirunelveli	Kanyakumari	Kanyakumari	Kanyakumari
70 - 80	Madurai Thanjavur Tiruchirapalli Ramanathapuram	-	Ramanathapuram South Arcot	-
60 - 70	Madras South Arcot North Arcot	-	Tirunelveli Thanjavur Tiruchirapalli	Tirunelveli Thanjavur Ramanathapuram Coimbatore
50 - 60	Chingleput	Coimbatore	Dharmapuri Chingleput	Dharmapuri South Arcot Tiruchirapalli
40 - 50	-	Madras Thanjavur South Arcot Dharmapuri Tirunelveli North Arcot Ramanathapuram	Salem Coimbatore	North Arcot Salem Chingleput
30 - 40	-	Chingleput Tiruchirapalli	North Arcot	-
20 - 30	-	-	-	Madurai Madras
10 - 20	-	Salem	Madurai	-
0 - 10	-	Madurai	Madras	-

Compiled by the author from unpublished Public Health records.

11 year period (1961-74) indicate that Madras (46.4 percent) ranked high in its level of persistence, followed by North Arcot (46.4), Madurai (51.2), Salem (57.7), Chingleput (61.9), and South Arcot (64.9). The northern coastal districts and one interior district (Salem) appeared to be the endemic foci during this period.

In terms of attack-free months, high persistence levels were again found in Madras (23.2), Madurai (29.7), Chingleput (45.8), Salem (47.0), North Arcot (48.2), Tiruchirapalli (54.7), South Arcot (58.3), and Dharmapuri (59.5) (Table 6b).

Degree of Endemicity of Cholera by Districts, 1956-1974

The degree of endemicity of individual districts has been determined by examining the average cholera death rate for the five years and recording the three lowest monthly incidence rates for each year. This rate gives the minimum level at which the incidence of disease occurs in each district. The lower the level attained by the disease, the lesser is the degree of endemicity (Swaroop, 1951). The term "endemicity" must be used with caution; here it is used in a relative sense. The terms "highly endemic", "moderate" and "low endemicity" are used only in relation to each other. Their relative values for each district for each selected period interval are shown in Figures 9 and 10. Although this analysis does not demarcate endemic areas in any absolute sense, broad patterns at district levels are illuminated, in the absence of data for smaller units (taluks, blocks or villages) in the State. The index is calculated as follows: monthly district figures of death rates and attack rates per 100,000 were taken for each year and arranged in ascending order and the first three lowest figures in twelve months were taken. Such figures (3 x 5 = 15) for all 5 years, e.g., 1961-65, were added (a total of 15 figures) and divided by 15 to give an average minimum monthly incidence rate per 100,000 population for 1961-65.

1961-65 (Endemicity Index based on Cholera Deaths)

Relatively high endemic districts were Thanjavur (1.709), Dharmapuri (0.831), Madras (0.821) and Salem (0.523). The moderate ones were found in Coimbatore (0.493), South Arcot (0.349), Madurai (0.344), Tirunelveli (0.329), Tiruchirapalli (0.299), Chingleput (0.258) and Kanyakumari (0.238). More numbers of districts fell into the moderate endemicity category (Figure 9). Ramanathapuram occupied a low value (0.085), followed by endemic North Arcot (0.189).

1966-70

The intensity of endemicity has come down. This is evident from the fact that no district registers more than one (a unit value of one). In the overall pattern, Dharmapuri continued to have a higher value (0.990), with Madras (0.78) and Tirunelveli (0.670). Madurai exhibited a low index followed by Tiruchirapalli (0.063) and South Arcot (0.098), while the rest of the districts occupied relatively moderate categories. Zones of high values were scattered throughout different parts of the State, with the least endemic zone located in the central part. As compared with previous periods, the higher figures have shifted from Thanjavur to Dharmapuri and Tirunelveli, both of which occupy the upper part of the river basins, Cauvery and Tambaraparani respectively (Figure 9).

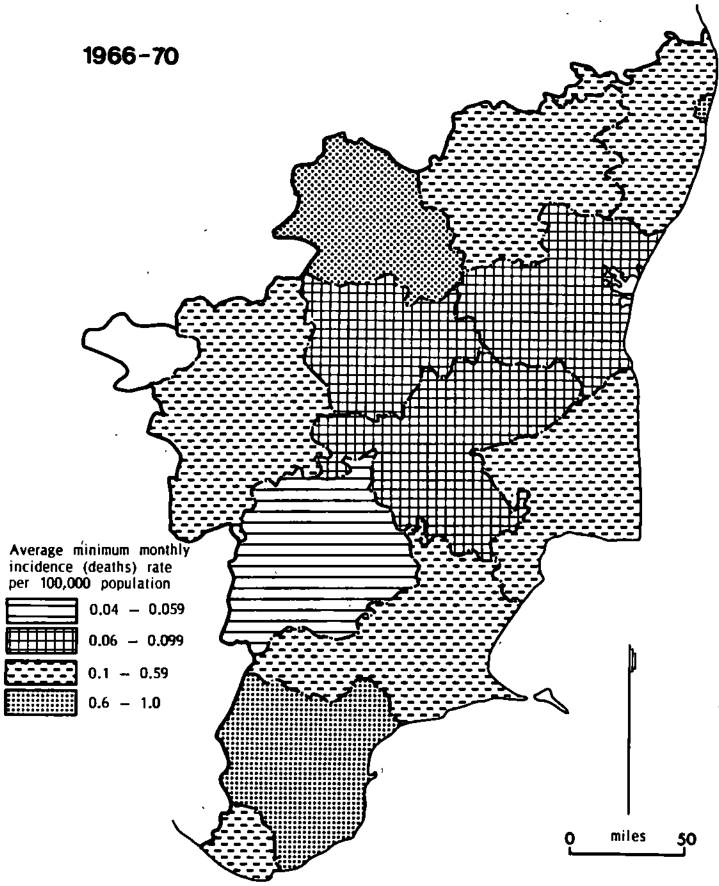
1971-74

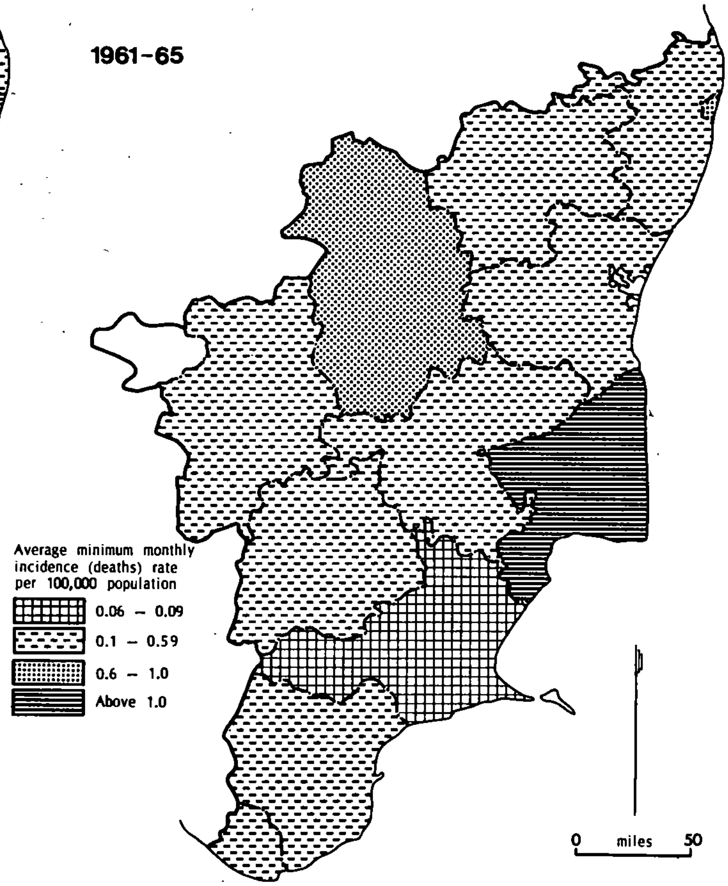
The index values have come down significantly, obviously indicating the decreased intensity of the disease. Kanyakumari (0.172) appeared to be the endemic area followed by Thanjavur (0.139). The present high index represents the lowest index value of the earlier periods, the lowest index ranging from 0.02 to 0.05, was not seen during the earlier periods (Figure 9). Madurai represents the lowest figure (0.026), followed by South Arcot (0.040), Chingleput (0.05), and North Arcot (0.052). Spatial shifts in endemic zones shows Thanjavur once again in the endemic zone as noticed in 1961-65. However, the value of the index is definitely low, that is, less than 10.

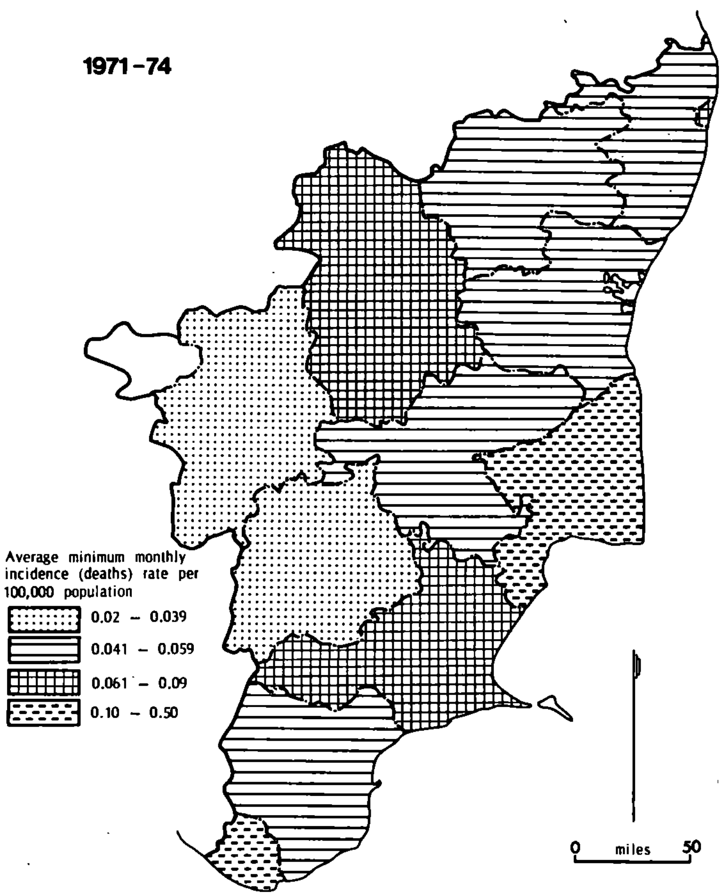
1961-74

The average minimum monthly death rate for the entire period identifies Thanjavur (0.70), Dharmapuri (0.36) and Madras (0.340) as high endemic areas. These values are extremely low (less than one), although over an average of the five-year period, fluctuations are observed. Moderate incidence persisted in the interior districts of Salem, Dharmapuri and Coimbatore, apart from Thanjavur and Madras. Low endemicity was observed in the northern coastal districts, central parts of Madurai and Tiruchirapalli districts and the southern districts of Tirunelveli and Ramanathapuram.

Fig.9 DEGREE OF ENDEMICITY OF CHOLERA, BY DISTRICTS, TAMIL NADU, 1961-74.







1961-65 (Endemicity Index based on Cholera Attacks)

In the case of attacks, all the districts of the State, with the exception of Nilgiris, were affected. Madras (3.78) and Thanjavur (3.68) ranked high in this time period, whereas Salem (10.28), Madurai (1.519), and Dharmapuri (1.863) were moderately affected. Both the upper and lower part of the Cauvery Valley acted as an important zone of attacks (Figure 10).

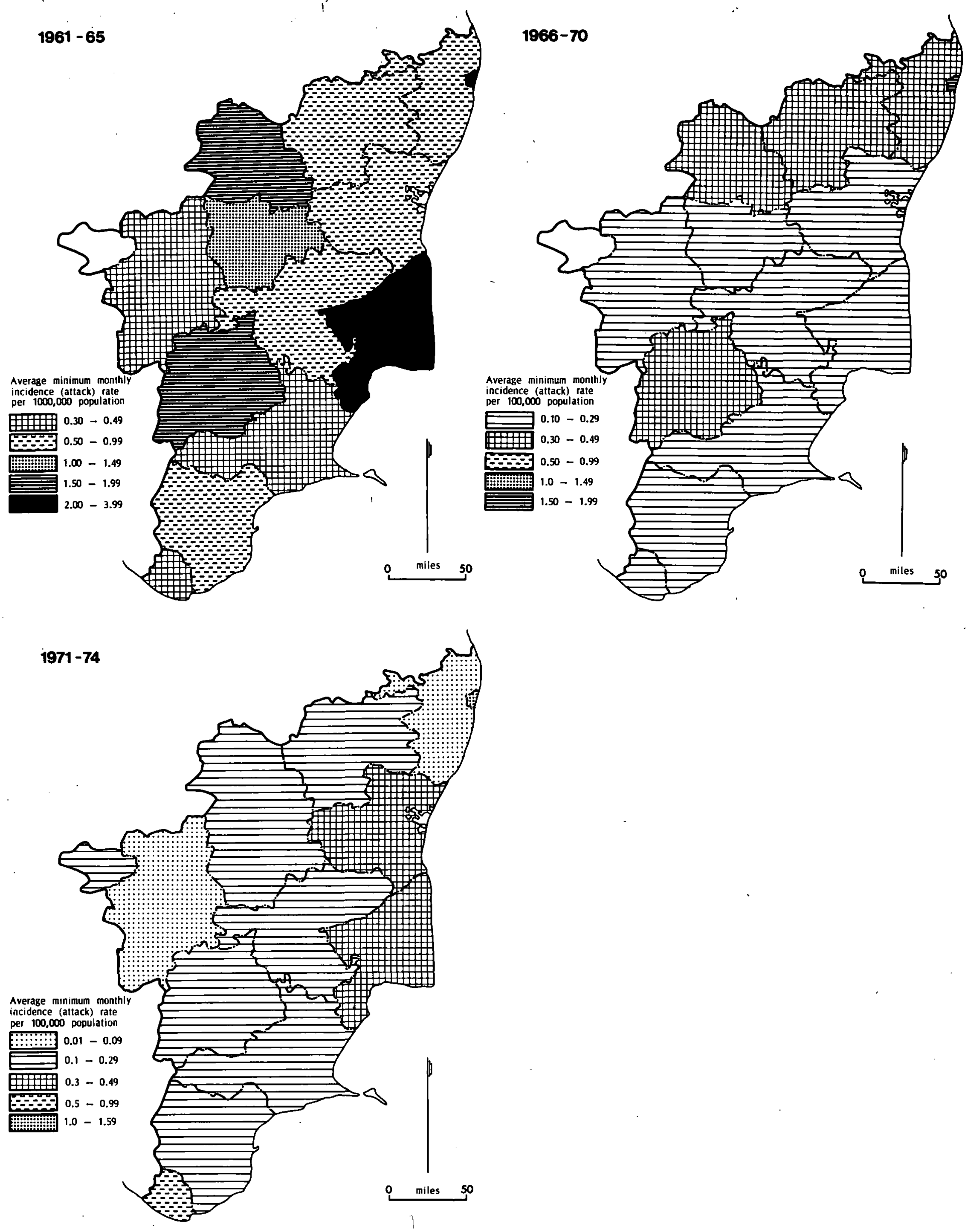
1966-70

The lower values of the endemicity index during this period clearly show a lesser intensity of attack all over Tamil Nadu. The highest is found in Madras (1.526), followed by Madurai (0.464). Significant zones were found in the north with relatively moderate rates in Madras (1.526), Chingleput (0.318), North Arcot (0.310) and Dharmapuri (0.304). Madurai showed an index value of 0.464.

1971-74

Endemicity values were extremely low (less than one) during this period, as compared to previous periods, however a large number of districts (6) in the relatively moderate endemicity group (0.30 - 0.49) indicate that attacks were more prevalent than deaths in Tamil Nadu. Noticeable attacks were concentrated in South Arcot, Thanjavur, and Kanyakumari districts, the highest with a value of 0.54. Madras continued to occupy the most prominent position (1.315). The interior districts, except Coimbatore, appeared to have experienced incidence of cholera. Patterns appear to be diffused, and no easy explanation has been available for the

Fig.10 DEGREE OF ENDEMICITY OF CHOLERA BY DISTRICTS, TAMIL NADU, 1961-74.



somewhat alternating zones of attacks occuring in the State during 1971-74.

1961-74

The overall pattern with regard to endemicity (attack rates) for a period of 14 years shows Madras (2.27) and Thanjavur (1.520) as the high concentration zone, followed by Dharmapuri (0.820) and Madurai (0.740) (Figure 10).

Total Number of Registered Deaths Due to Cholera by Taluks, 1961-1973

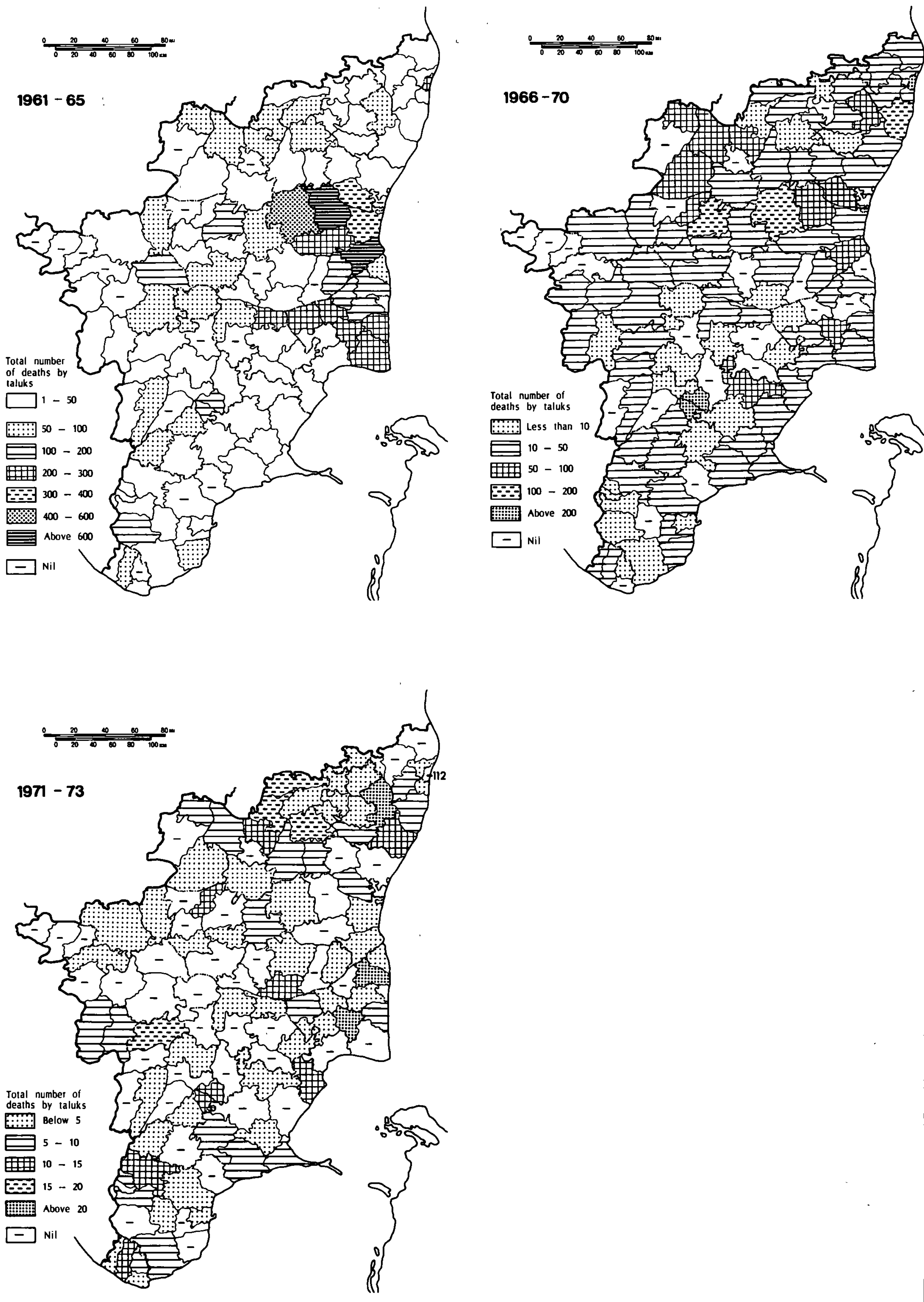
1961-65

The highest number of deaths were reported from the taluks of Chidambaram (955) and Tirukoilur (893) in the South Arcot district, followed by two other taluks, Vriddhachalam (410) and Villupuram (373), in the same district (Figure 11). A significant number of deaths (200-300) were reported from five taluks in endemic Thanjavur districts, and in isolated pockets (100-200) from Madras, three taluks in North Arcot, Salem, Erode, Tiruchi, Madurai, Ambasamudram, etc. Except for fifteen taluks, and a few scattered ones, almost all taluks reported cholera during this five-year period.

1966-70

Deaths were found significantly lower in number than during previous periods. The highest rate was reported in Madras (246), followed by Madurai (202); Salem (136) and Kallakurichi (106) in South Arcot reported more than 100 deaths. Endemic tracts were found mainly in the South

Fig. II REGISTERED DEATHS FROM CHOLERA BY TALUKS, TAMIL NADU, 1961-73.



Arcot and Dharmapuri districts. Most of the taluks were concentrated in the range 1-30, while only 15 taluks reported no deaths. Diffused pattern is apparent during this period.

1971-73

Total registered deaths were even lower than in the period 1966-70. A larger number of taluks (41) did not report deaths in this period than in 1966-70. Highest reports for this period were concentrated in Madras (112) and Kancheepuram (39) in the Chingleput district, followed by two taluks, Mayuram (37) and Mannargudi (20), in the Thanjavur district. Four North Arcot taluks, Gudiyatham, Polur, Vaniambadi, and Tiruputhur (Appendix 1) reported deaths in the range 15-20 (Figure 11).

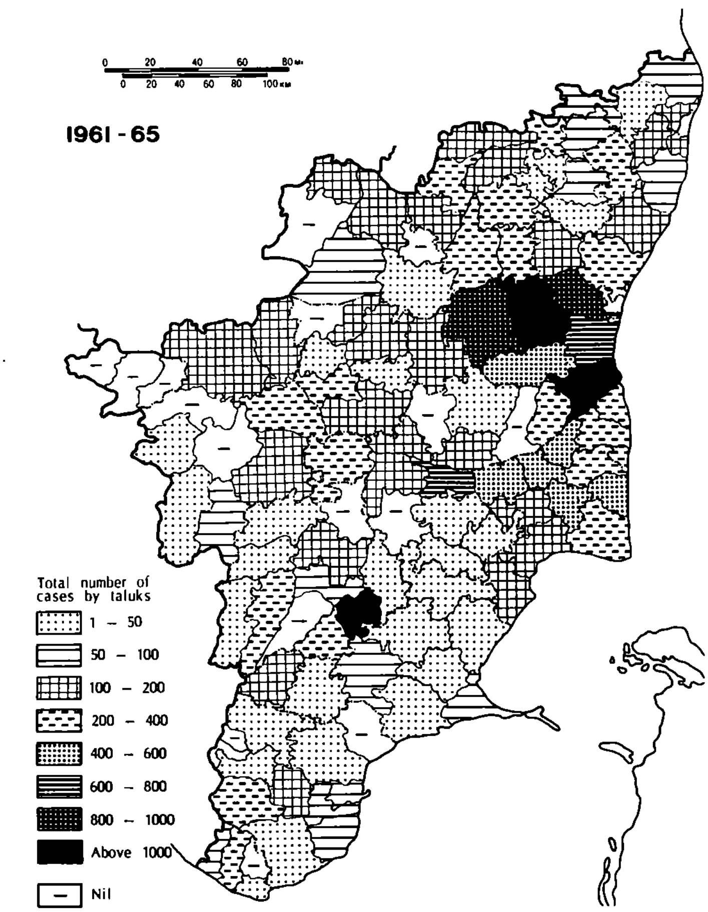
Notified Cases of Attacks by Taluks, 1961-1973

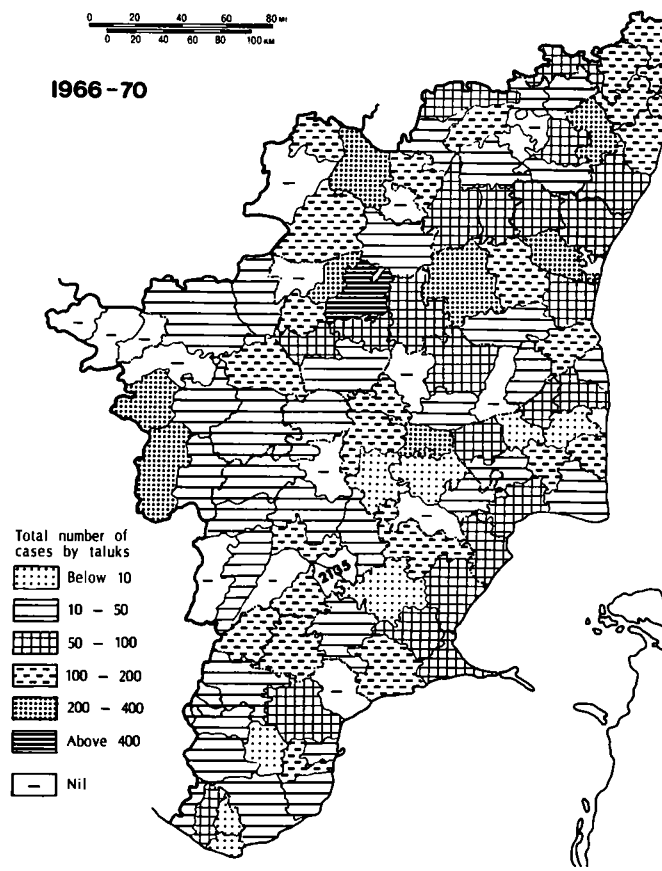
Twelve taluks did not report cases; all the others reported cases of cholera. The largest number of cases was reported from Madras (3,678) and Madurai (1,183), while endemic taluks in the South Arcot and Thanjavur districts reported the next highest, ranging between 600-1,000 in South Arcot and 200-600 in the Thanjavur district (Figure 12). North Arcot emerges as a second, smaller foci, in the range 200-400. Scattered cases were reported (range 100-200) mainly from the taluks in Coimbatore, Salem, Dharmapuri and Madurai.

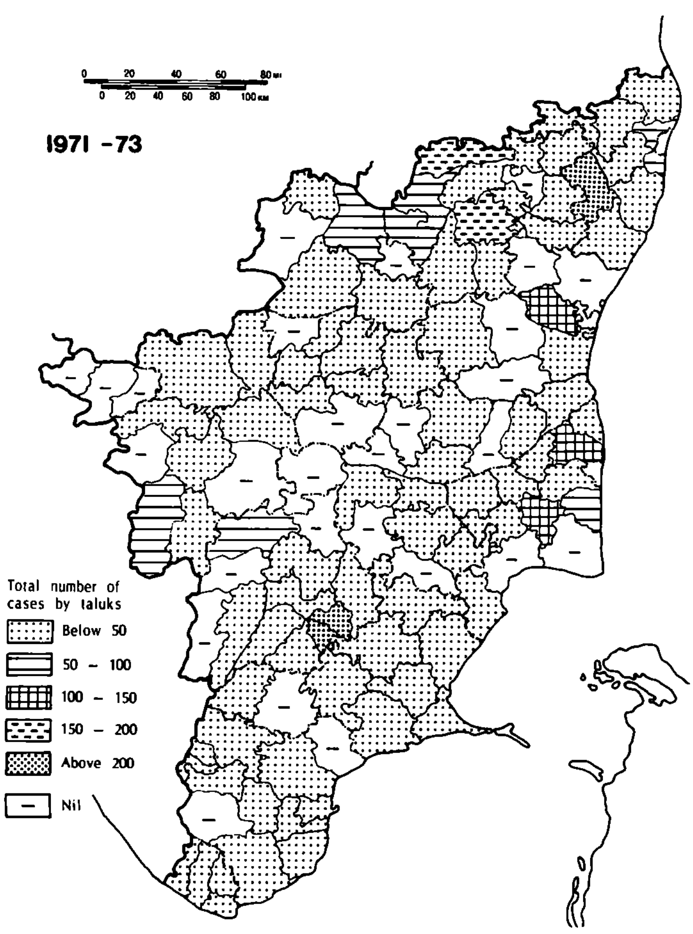
1966-70

All the taluks, except fifteen, reported cases of cholera during this

Fig. 12 NOTIFIED CASES OF CHOLERA BY TALUKS, TAMIL NADU, 1961 – 73.







period. Madras (7,571) and Madurai (2.135) continued to report the largest number of cases. A diffused pattern again appeared. Taluks reporting cases in the range 200-400 were in South Arcot, Salem, and Dharmapuri, while smaller numbers of attacks (100-200) were reported from various taluks in all the districts (Figure 12).

1971-73

Madras (4,772) and Madurai (724) continued to occupy the most prominent position. A large number of taluks in the North Arcot and Thanjavur districts exhibited endemicity during this period. A large number of random taluks (25), scattered throughout the State, did not report cases of cholera (Figure 12).

The Overall Pattern of Changes in the Incidence of Cholera from 1961 to 1974

In order to assess the endemic significance of the areas studied, several measures were used in this section to study the distribution pattern of cholera deaths and attacks in different districts of Tamil Nadu. The following categories of figures were examined at five-year intervals for each district of Tamil Nadu: (1) average annual death rates and attack rates; (2) total number of registered deaths and cases due to cholera; (3) persistence level as measured by free periods (monthly percentages) from cholera attacks and deaths; and (4) endemicity index, showing average minimum monthly incidence rates. The districts were ranked according to high, moderate and low figures to study the persistence level.

It is noted from Table 7 that during the period 1961-65, the Thanjavur and South Arcot districts emerged as major endemic foci. Minor foci were identified in North Arcot, Madras and Tiruchirapalli.

However, a shift took place during 1966-70. Even though Madras and Madurai continued to report cholera cases, higher numbers of deaths were reported from the interior districts of Dharmapuri and Salem. The northern coastal and adjoining districts of Chingleput and North Arcot began to appear as endemic foci. The persistence level was no longer noticed in the endemic Thanjavur district, but in Salem, it seemed to continue at a low level. During 1966-70, a fairly large number of districts in Tamil Nadu experienced incidence in cases of cholera as compared to the previous years, 1961-65. The pattern was somewhat diffused rather than being concentrated in a few small foci.

During 1971-74, the northern coastal districts (North Arcot, Chingleput, and Madras) of Tamil Nadu appeared to be the major zones of incidence. Madurai and Thanjavur also continued to remain in the picture. An epidemic in Kanyakumari in 1973 brought it to the forefront, whereas in previous years Kanyakumari was less noticeable. The interior districts of Salem and Dharmapuri also began to exhibit relatively high persistence levels during this period.

This section presents a picture of the level of endemicity of each district due to cholera infection during different periods. For the entire period, it is seen that cholera incidence persisted at relatively moderate levels in the northern coastal districts of Madras, Chingleput, North Arcot, South Arcot and Thanjavur, while the interior districts of

TABLE 7

DISTRICTS IN ORDER OF IMPORTANCE AS REGARDS ENDEMICITY OF CHOLERA, TAMIL NADU, 1961-1974
(Districts in first four high ranks are shown)

Endemicity Levels	1961-1965		1966-1970		1971-1974	
	Rank 1 & 2	Rank 3 & 4	Rank 1 & 2	Rank 3 & 4	Rank 1 & 2	Rank 3 & 4
1. Average annual death rate	South Arcot Thanjavur	North Arcot Tiruchirapalli	Dharmapuri Salem	Madras Chingleput	Madras North Arcot	Thanjavur Chingleput
2. Average annual attack rate	South Arcot Madras	Thanjavur North Arcot	Madras Madurai	Chingleput Salem	Madras Chingleput	Madurai North Arcot
3. Total number of registered deaths due to cholera	South Arcot Thanjavur	North Arcot Tiruchirapalli	South Arcot Salem	Madurai Madras	Madras North Arcot	Thanjavur Chingleput
4. Total number of notified cases of cholera	South Arcot Thanjavur	Madras North Arcot	Madras Madurai	Chingleput Salem	Madras Chingleput	Madurai North Arcot
5. Persistence level-(percentage of months free from cholera deaths)	North Arcot South Arcot	Tiruchirapalli Ramanathapuram	Madurai Salem	Chingleput Ramanathapuram	Madras Madurai	Salem Coimbatore
6. Persistence level-(percentage of months free from cholera attacks)	Chingleput South Arcot	North Arcot Madras	Madras Madurai	Tiruchirapalli Chingleput	Madras Madurai	Salem Chingleput
7. Average minimum monthly incidence rate (deaths)	Thanjavur Madras	Dharmapuri Salem	Dharmapuri Madras	Tirunelveli Kanyakumari	Kanyakumari Thanjavur	Madras Dharmapuri
8. Average minimum monthly incidence rate (attacks)	Madras Thanjavur	Dharmapuri Madurai	Madras Madurai	Chingleput North Arcot	Madras Kanyakumari	South Arcot Thanjavur

Compiled by author.

Salem, Dharmapuri, Coimbatore, Tiruchirapalli and Madurai also exhibited moderate levels of persistence in its incidence. In the remaining southern districts of Ramanathapuram, Tirunelveli and Kanyakumari (except in 1973) only sporadic cases were reported.

The difficulties are apparent in attempting to draw inferences regarding the comparative cholera incidence patterns of different districts. As discussed earlier, for instance, the registration efficiency in the districts may not be uniform throughout the periods considered. However, some generalizations were made concerning persistence and endemicity in different areas by examining the trends in mortality and case occurrence for fourteen years. The distribution of disease and its changing pattern of incidence, if any, and the degree of intensity clearly show the amount of control that has been achieved. The declining trend in cholera occurrence, as evidenced by the data presented in this section, indicates the extent of control over incidence and spread, particularly since 1960 in the study area. The importance of the study of the distribution of communicable diseases like cholera need not be emphasized. It helps in determining the nature and kind of health services and preventive medicine required and where they are needed. Diseases are liable to change subtly and unnoticeably in distribution and occurrence, due to such factors as environment, population movement and carriers. This calls for a well-established surveillance network for early detection and control of spread. Some of the problems related to its prevention and control are discussed in the following section.

PART IV

EPIDEMIOLOGY AND THE PROBLEM OF THE ENDEMICITY OF CHOLERA

This section will relate some of the observations from the previous section to various known epidemiological factors that might influence distribution factors such as the nature of the disease, suspected agents in transmission, host susceptibility and environmental conditions. This section will assess the current situation in Tamil Nadu in terms of information available through field enquiries with the Public Health officials, printed documents, and research literature on the subject of the epidemiology of cholera. Some findings encourage the formulation of certain hypotheses about the causation of disease. As stated by Miller, "There are three primary questions concerning the epidemiology of communicable disease: What is the agent causing the disease? How does it reach one host from another? What determines whether or not it will cause illness? From these basic questions flow a series of subsidiary questions concerning the properties of the agent that determines its pathogenity, the circumstances that favor its transmissions and and the factors that affect the relationship between the agent and the host, particularly the host immunity" (p. 16).

Three factors concerning communicable diseases are examined: those relating to the properties of the agent that affects pathogenity and mode of spread; environmental conditions that assist spread; and the host's ability to resist infection and the illness that may result (Miller, 1970, p. 17). The agent and host characteristics are discussed in general, as they are basically the same in all areas, but environmental conditions that favor infection and the development of the disease are investigated specifically with reference to Tamil Nadu. It is necessary to review briefly the nature of the disease before proceeding to examine other factors concerning the persistence of cholera in an endemic foci.

The Nature of the Disease, Cholera

Cholera is a common intestinal disease caused by bacillus Vibrio Cholerae or Vibrio Comma. Included among the vibrios is the El Tor strain (developed since 1961) which has been identified as causing para-cholera. Numerous strains of vibrio are recognized, but their role in causing the disease has not been completely established. The definition of the true cholera germ is yet controversial and organisms other than the accepted cholera organism are now considered to be capable of causing choleraic symptoms (Seal, 1960, p. 4). Isolating the so-called "true cholera" germ has not been possible in more than eighty percent of the cases, even with the best of technical ability and adequately equipped laboratories; the true cholera vibrio is generally missed unless the stool is examined within 6 hours of onset of first symptom. It is impossible to identify the cholera vibrio cases in rural areas without well-equipped laboratories and specifically trained bacteriologists (Seal, 1960, p. 14).

According to a World Health Organization Report, identification of an infectious disease caused by vibrio cholerae would require bacteriological facilities and skills adequate for the study of every incident of dehydrating diarrhoea (W.H.O., 1967b, p. 4). The spectrum of infection ranges from a severe, dehydrating diarrhoeal disease resulting in death within a few hours, to less severe illnesses, including diarrhoea with no dehydration, to asymptomatic infections. The number of asymptomatic infections varies in different localities and population groups from five to ten or more per typical cholera case. In endemic areas, mild diarrhoea due to vibrio cholerae exists described as "non-vibrio cholera" and "non-vibrio cholera-like disease", from which no known pathogenic agent has been recovered; this condition, occurring only among adults, is indistinguishable on clinical grounds from cholera during early stages of illness, but differs by the length of purging which ceases within one or two days (true cholera lasts up to 7 days) (W.H.O., 1967b, p. 4).

El Tor biotypes of vibrio cholera have now become more prevalent, especially since 1963 in different parts of India including Tamil Nadu. Though cases are reported in large numbers, mortality from this type of cholera is low. This type, milder than vibrio cholera, is not yet fully understood; in many cases it appears indistinguishable from classic cholera. So far, it has been found to be slightly more resistant to various environmental factors and antibiotics, therefore surviving longer in the environment, although the difference is not of epidemiological significance. Few secondary cases are found in families (W.H.O., 1970,

p. 130). According to W.H.O., epidemiological investigations of El Tor cholera outbreaks in some populations have shown that relatively few typical cases occur; many symptomless carriers are detected. Mild diarrhoea often occurs in apparently healthy carriers who very frequently prove negative to routine bacteriological tests. "The carrier state in El Tor infection probably can last more than 10 days and the vibrio has been known to establish itself in the gall bladder; even after the successful treatment of a cholera patient, with or without antibiotics, he may continue to excrete vibrios periodically" (W.H.O., 1966, p. 256).

A majority of infection due to vibrio cholera remain undetected, according to W.H.O., and very few hospitalized cases are noted. "However, high frequency of inapparent infection, mild disease, isolation and quarantive practices have proved ineffective in the control of cholera epidemics" (W.H.O. Chronicle, 1966, p. 256).

Vibrio cholera's properties can be noted in terms of its transmission cycle, incubation period and carrier status. Some believe that the methods of transmission of the vibrio cholera have not been clearly established. A study of several cases of both classical and El Tor biotypes in Calcutta did not show any significant difference in the course of the disease. Carrier rates are found to vary with the type of community and locality rather than with the biotype (W.H.O., 1967b, p. 7). The disease is transmitted via the aual/oral route; the causative organism can be identified in the feces of patients, convalescent carriers and asymptomatic individuals. During the acute stage of the disease, the organism is present in vomitus but is not present in the urine. Transmitting agents are commonly found in contaminated water supplies, foods such as milk, fruit, and vegetables. After entering the human body, the development of the vibrio is dependent upon the amount of gastric juices (hydrochloric acid) present in the stomach. Undiluted gastric juices will kill the organism. It is pointed out that people who consume curds or fresh lime juice contain high quantities of this acid in their stomach and thus acquire immunity (Shattuck, 1951, pp. 314-318). Susceptibles (host human beings) exclude those who possess natural immunity, those who have acquired brief immunity after innoculation (lasting about 5 to 6 months), and those who have had recent attacks (with immunity lasting about 1 to 2 years). Reinfection is possible, however.

Incubation period for this disease varies from 24 hours to 5 days. In one common source, the median period was found to be 48 hours (Mosley, 1970, p. 26). W.H.O. reports that "cholera carriers may be incubatory, convalescent, contact, or, very rarely, chronic ... the convalescent carrier may persist in a person for 2 to 3 weeks, the period of excretion of vibrios by the contact carrier is short, possibly 5 days to 2 weeks". Chronic carriers are rare; one person who has been found to harbour the vibrios in her gall bladder has been excreting the organism intermittently for over eight years. The role of chronic carriers in maintaining cholera infection has not been fully established (W.H.O., 1970, p. 130).

Studies in deltaic regions of Tamil Nadu and West Bengal by Indian authors (Russell and Sundararajan, 1928) indicate that the period of persistence is usually not more than 13 days in humans and 16 days in water source nearby. Ordinary water, alone, cannot be the major source of infection; for example, experiments at Khulna and Cauvery showed that the source of infection could not be traced to the water. According to Seal, twenty-five years of experimental studies in endemic areas of West Bengal showed that human beings are the major reservoir of cholera; environmental agents such as water, flies, etc., play a temporary or secondary role in the process of transmission (pp. 13-14).

Even though the infection can occur through either clinical cases or carriers, the carrier is considered to be more significant in the overall process of transmission (W.H.O., 1967b, p. 14). Asymptomatic infections represent the principal source. These "occur 5-10 times as frequently as cholera cases. Although the formed stools of asymptomatic carriers contain only 10^2-10^5 vibrios per gram the relatively large number of carriers and their freedom of movement makes them a practical threat. The untreated symptomatic patient passes vibrios for one or two weeks, whereas the excretion of vibrios by a person with an asymptomatic infection usually ceases at the end of one week. However, the chronic carrier with a persistent focus of infection may shed organisms intermittently for an indefinite period. The chronic infection generally seems to be in the biliary tract and can be detected by culturing duodenal fluid after the administration of a chlorogogne"(W.H.O., 1967b, p. 13). W.H.O. refers to epidemiological evidence from Hong Kong, Taiwan, Philippines and India indicating that the chronic carrier often serves as the source of infection and plays an important role in the persistence of the disease and its transmission, either within a given population or between neighboring countries. Because the chronic carrier becomes a reservoir of the disease, this kind of carrier may contribute heavily to the perpetuation of infection from season to season. The detection and control of all chronic carriers is impossible because of infrequent and intermittent passage of organisms. Although carriers may be recognizable by their high level of persisting antibodies, serological screening of large populations is not feasible (W.H.O., 1967b, p. 19).

Outbreaks of cholera epidemics during the fairs and festivals are attributed to the presence of human carriers in several earlier studies by the Indian authors (Swaroop and Raman, 1951; Rogers, 1952). Hundreds of thousands of people congregate, and the presence of even one or two carriers will be enough to contaminate the water facilities like rivers and tanks in these centers. No typical cholera vibrios could be detected at important pilgrim centers, either in human beings or in the environment during the inter-epidemic periods (Seal, p. 14). Very few case studies have been conducted so far on different aspects of cholera carriers in India. A study conducted in Delhi between June and October, 1968, confirms that carriers exist in non-endemic or low-endemic areas, that they are of short duration, and that the carrier rate was highest among the family contacts of cholera patients (Pal, et.al., 1973). While in hyper-endemic areas large numbers of carriers were detected, and even in the absence of cases of cholera, "no carriers were present during the inter-epidemic period, (November to April) as examined from latrine samples and clinical cases of diarrhoea and gastroenteritis, when no overt case was reported" (Pal, et.al., 1973). Carriers represent potential reservoirs of infection and are of particular concern in control prevention efforts. As far as this study area is concerned, carrier studies are now just beginning to be taken up in King Research Institute of Preventive Medicine in Madras. Chingleput district, adjoining Madras City, has been marked for 'carrier' research. The results of this study are not documented or available to the public.

Environmental Factors Favoring the Transmission and Spread of Cholera

Many environmental factors are thought to cause cholera outbreaks, as well as establish its persistence in certain areas, thereby creating endemic situations. If the number of carriers goes unchecked, cholera cases assume epidemic significance. Even though person-to-person transmission of the infection occurs, environmental factors, especially water, have assumed great significance in cholera spread. This is evidenced by many epidemiological studies of this disease. Barua observed that "since discovery of the causative organism of cholera, many investigations have been carried out on the survival of vibrio cholera in the environment, but unfortunately there has been no uniformity in the type or state of contaminating agent, method of sampling, experimental condition of temperature and p.H., techniques of isolation of vibrios from the contaminated samples, etc." (1970, p. 29). The survival and spread of vibrios in the environment depends on several factors, physical as well as socio-economic conditions (Appendix II). The transmission of cholera from a carrier to a susceptible individual depends on the ingestion of a sufficient number of vibrios under conditions that favour infection and the development of the disease (W.H.O., 1970b, p. 14).

The W.H.O. Committee on Cholera believes that cholera can occur if vibrios are introduced in any part of the world where overcrowding and poor sanitation exist. The establishment of endemicity requires that sewage and waste disposal practices be sufficiently poor to favour persistence of excreted vibrios within the environment. Poor water hygiene may lead to intensive contamination of the water (W.H.O., 1967b, p. 14).

Evidence from various case studies does indicate a strong relationship between the natural and cultural environment, and cholera incidence in many parts of India. Some of these factors have been summarized in Appendix II. Selected factors have been used in discussing the status of the study area. As Appendix II indicates, the numerous and complex factors involved in the relationship between cholera occurrence and environment so far defies any comprehensive analysis for arriving at one simple solution to the problem of control, prevention and eradication.

The Problem of Cholera in Endemic Areas of Tamil Nadu: An Overview

In characterizing the disease in the previous section, a general pattern of distribution was clearly identified. The distribution maps were found to present no definite pattern or consistency which made it difficult to formulate relationships explainable in strictly geographic terms. Because of the limited information available on the epidemiology of the disease in different areas of the State, existing patterns observed from maps could not be explained. Collection of information was difficult. Printed documents or research studies relating to the epidemiological significance of the disease to the natural and cultural environment in the study area were scarce. Hence, it was not possible without intensive field surveys to find direct relationship between the environment and the incidence and spatial distribution of the disease. However, the following observations were made on the status of cholera incidence in Tamil Nadu, after personal discussion with health officials, epidemiologists for the State, and epidemiologic statisticians in the Department of Public Health, and from the information obtained from the recent Perspective Plans for health and rural development programs in Tamil Nadu.

Because cholera is primarily water-borne in Tamil Nadu, it appears traditionally in those areas encompassing the confluence of rivers and streams, in wet areas such as paddy fields, etc., and in river valley deltas and coastal tracts.

The Cauvery River Delta was found to be the main endemic area in the State, followed by other river valleys like Vaigai in the Madurai district, Tambaraparani in the Tirunelveli district, Palar in North Arcot and Chingleput districts, and Pennar in South Arcot. Thanjavur, South Arcot, North Arcot and Tiruchirapalli are considered the main endemic districts in the State; other districts such as Madurai, Dharmapuri are endemic to a lesser degree. Recently, Madras City and Madurai City have been reporting year-round cases of cholera, thereby indicating an increase in urban incidence, increasing with the rate of urbanization. Also, their status as corporate cities has provided them with better registration and notification systems than other areas.

Before an advanced transportation network was introduced by British India, incidence followed the river systems in its pattern of spread. Infection often spread downstream along the rivers, such as in the Cauvery River basin pattern, which spread downstream from Mysore State through the Dharmapuri and Salem districts to Tiruchirapalli, and to the deltaic regions of the Thanjavur district. This pattern appeared to change with the development of railroad systems, although some parts of this system follow riverine routes. Now the infection can be easily transmitted from Madras City to Coimbatore, for example. Thus, a 'leap frog' effect is seen outside of these endemic foci, illustrating that there is no definite route now which can be traced easily.

This pattern is further complicated by agricultural and labour migrations, both internal and external, in the State. Lack of information or study on migratory routes adds to the difficulty of explaining incidence patterns. For example, certain taluks which are considered the most important groundnut-growing areas in the State, attract a large number of migrants from the southern districts during groundnut season. Incidence of cholera seems to increase during the groundnut season in these areas which include taluks like Coimbatore and Pollachi (in the Coimbatore district) and others in the districts of North Arcot, South Arcot, Tiruchirapalli, and Thanjavur. This was explained by Swaroop in his study in the Thanjavur deltaic region. Detailed studies are needed to prove this relationship; at present there is no clear-cut evidence to form conclusions around migration and incidence of cholera.

However, the environmental and cultural conditions on the East Coast of Madras (comprising the districts of Chingleput, North Arcot, South Arcot and Thanjavur) provide endemic foci for cholera occurrences here. This region enjoys ample rainfall during the retreating monsoon season (October-January), the highest proportion of net sown area under irrigation in the State and an extensive canal and tank irrigation system, as well as high density of rural population, and high death rates. Other cultural factors involved in the existence of endemic foci here are low standards of environmental hygiene and sanitation and greater population mobility, facilitated by agricultural activities and by many annual and seasonal fairs and festivals.

Seasonal Incidence Characteristics of Cholera in Tamil Nadu

In several earlier studies (Rogers, 1944; Russell and Sundararajan, 1928) seasonal influence was found to be significant in cholera incidence. At certain seasons, conditions are favourable for the development of cholera and its transmission. Of several physical factors such as temperature, humidity, rainfall and soils, rainfall is found to be related most closely to areas of cholera incidence. A study of cholera mortality figures by seasonal categories in Tamil Nadu indicated that cholera became epidemic during, or soon after, the major rainy season in the State.

Observations indicate that cholera follows monsoons with great regularity and depends upon the chief monsoon prevalent in each district. Variations in cholera incidence and mortality were found to occur seasonally with the north-east monsoon (October to December) and the south-west monsoon (June to September) which also determine the annual rainfall pattern. Cholera is found at its height in the December-January period, while a small peak of incidence occur in July-August. The State can be divided into three broad divisions on the basis of these two monsoons: (1) the northern coastal districts of Madras, Chingleput, South Arcot, Thanjavur, and North Arcot dependent mainly on the north-east monsoon; (2) the central districts of Salem, Tiruchirapalli, Coimbatore, Ramanathapuram and Madurai where both monsoons occur; and (3) the districts of Tirunelveli, Kanyakumari and the Nilgiris, where the south-west monsoon predominate. Average annual rainfall in the northern coastal districts of North Arcot, South Arcot, Chingleput and Thanjavur is higher than in the remaining districts, other than the Nilgiris and Kanyakumari. The lowest rainfall is found in the plateau region of Ramanathapuram, Tirunelveli and Coimbatore. This seasonal pattern of incidence in different districts could be explained to some extent by the information given in Figures 7 and 8.

An understanding of the seasonality of cholera occurrences will help formulate adequate public health measures at the proper periods of the year and a rational utilization of limited resources available for health planning.

Evidence regarding geographic variations in incidence and mortality due to heavy rainfall is limited; variations are often found to be the result of environmental factors which vary from area to area. For example, when dry conditions are severe and safe water supplies have dried up, cholera epidemics are liable to occur due to the use of contaminated and unsafe water supplies. In such areas, cholera decreases as water supply improves. It follows that when monsoons fail to materialize in low rainfall districts, periodic epidemics occur. In those dry regions such as the districts of Ramanathapuram and Tirunelveli, tank irrigation is overwhelmingly important, both in accounting for 95 percent of the net irrigated areas, and in effecting the spread of disease.

Cholera spreads with the irrigation season and, therefore, the extension of irrigated areas will probably extend cholera into the dry areas which are more or less free. The irrigation systems have seen considerable expansion in the State of Tamil Nadu since the first Five Year Plan, 1951-1955 (Demography and Vital Statistics, p. 163). The canals and canal-fed tanks form the major irrigation system in different districts: River Palar and its tributaries feed numerous chains of tanks in North Arcot while the Cauvery River system irrigates extensive areas in the Salem, Coimbatore, Tiruchirapalli and Thanjavur districts.

The maximum utilization of this system already can be seen in Thanjavur district, an endemic area with the highest proportion of irrigated land in the State. Compared to the coastal districts, the inner districts have a lesser proportion of cropped area under irrigation. Tank irrigation predominates in the districts of North Arcot, Tirunelveli, and Kanyakumari, whereas irrigation by wells occurs in the Salem and Coimbatore districts. Coastal districts, which have a relatively higher proportion of irrigation facilities, seem to be favourable for higher cholera occurrence.

Population Movements and Cholera Incidence

Studies have shown that in India there is a definite relationship between outbreaks of cholera and pilgrim centers holding fairs and festivals at peak seasons. Regardless of its origin, the spread of cholera has been due largely to the congregation of pilgrims in hundreds of thousands at certain seasons of the year, especially during the hot period of March-April, when the water resources are at their lowest and subject to easy contamination. The time of the year at which festivals are held is a significant factor in cholera outbreak. Sanitary conveniences are scarce in such centers; with the temporary invasion of people, even with every sanitary precaution having been taken, outbreak is still possible.

Seasonal attendance varies in many places. One center may have more than one important festival at the same time, so attendance and frequency are also considered to be of some importance. During festival periods, people are in a state of constant movement and rotation. Other than religious devotees entering these centers, there are hawkers, professional beggars, wandering merchants, lepers, sadhus and fakirs, who, thereby, become either easy susceptibles or carriers themselves in the process of disseminating infection (Raman and Swaroop, 1951, p. 41). In the endemic areas, a number of pilgrim centers are located in the river basins. Raman and Swaroop's study, however, found no evidence of high level of endemicity at or around the pilgrim centers (p. 43).

In Tamil Nadu, the 1961 Census Report for the first time published information on fairs and festivals; included by months for 1961, the number of festivals and the attendance for various districts of the State (Table 8). The observations indicate that the largest numbers of festival centers are found in Thanjavur district in the Cauvery deltaic region. Historically, Cauvery is considered the sacred river of the region, and has experienced the growth of a large number of pilgrim centers with their sacred temples along its river banks and at nearby locations. Other endemic districts experienced large numbers of fairs and festivals; such districts were North Arcot (820), Tiruchirapalli (619), followed by Salem (585), Madras (572), Coimbatore (525), and South Arcot (502). Attendance was in the hundreds of thousands, especially in the dry months of March and April. Seasonal attendance varies. Madras experienced the largest numbers (164,200) attending in the cool months of December and January when many of the cultural events (music, drama, dance, exhibitions, etc.) take place. Figures 13 and 14

TABLE 8

NUMBER OF FESTIVALS AND (ESTIMATED) NUMBER OF ATTENDANCE BY SEASONS IN DIFFERENT DISTRICTS OF TAMIL NADU, 1961

(No. = Number of festivals)

District	January/ February		February/ March		March/ April		April/ May		May/ June		June/ July	
	No.	Attendance	No.	Attendance	No.	Attendance	No.	Attendance	No.	Attendance	No.	Attendance
Madras	15	18,860	30	48,950	40	166,510	46	146,010	26	121,100	9	9,275
Chingleput	41	567,550	22	699,120	25	252,900	91	336,912	56	335,100	23	117,350
North Arcot	266	340,950	48	176,815	72	125,790	146	194,707	70	107,875	32	49,855
South Arcot	71	182,850	37	134,950	63	340,900	109	208,560	59	119,400	20	31,350
Dharmapuri	62	94,770	18	67,700	17	42,000	45	78,250	25	40,300	5	6,700
Salem	75	141,565	97	279,240	192	271,105	83	99,025	29	41,450	7	9,500
Coimbatore	69	174,200	75	256,900	115	520,225	64	165,110	30	79,450	5	11,800
Nilgiris	17	18,050	12	20,300	4	2,600	10	39,500	2	550	1	10,000
Madurai	12	*	32	*	76	*	57	*	36	*	16	*
Tiruchirapalli	31	60,900	54	69,158	144	239,019	199	311,608	74	259,669	35	71,853
Thanjavur	17	*	29	*	42	*	101	*	69	*	22	*
Ramanathapuram	48	100,191	19	211,610	63	340,110	23	51,700	40	359,265	22	53,700
Tirunelveli	20	111,100	10	137,000	18	71,800	31	176,900	14	61,200	3	64,000
Kanyakumari	8	80,000	9	123,000	14	86,500	6	27,500	3	56,750	3	3,500

..........continued

TABLE 8 (continued)

District	No.	July/ August Attendance	No.	August/ September Attendance	No.	September/ October Attendance	No.	October/ November Attendance	No.	November/ December Attendance	No.	December/ January Attendance	Total Number of Festivals
Madras	88	50,000	103	27,500	60	134,850	43	131,200	27	122,100	85	164,200	572
Chingleput	74	576,005	35	109,165	28	150,000	18	223,075	14	414,275	21	248,500	448
North Arcot	85	114,623	31	30,590	13	120,100	24	35,470	19	35,095	14	16,680	820
South Arcot	80	115,470	20	12,320	7	4,750	18	23,100	10	28,000	8	55,000	502
Dharmapuri	13	31,050	8	72,000	7	59,300	0	-	0	-	4	2,900	204
Salem	23	91,050	15	41,100	1	2,000	30	43,350	15	24,650	18	38,820	585
Coimbatore	18	35,950	19	123,550	28	82,250	41	222,225	13	33,600	48	67,425	525
Nilgiris	2	3,400	0	-	1	8,000	0	-	2	3,000	4	4,000	55
Madurai	19	*	5	*	20	*	14	*	8	*	7	*	302
Tiruchirapalli	30	32,500	18	25,900	10	13,050	5	6,475	6	9,600	13	48,975	619
Thanjavur	28	*	15	*	12	*	17	*	7	*	16	*	375
Ramanathapuram	21	306,900	8	50,200	41	95,416	19	31,390	5	16,029	8	13,350	317
Tirunelveli	12	98,000	15	68,600	22	61,100	22	81,700	3	16,000	10	73,850	180
Kanyakumari	1	4,000	4	69,000	4	7,500	5	20,000	3	15,000	11	125,300	70

Compiled from: India, Census of India, 1961, Vol. IX, Madras: Fairs and Festivals, Part VII-B (Madras: Government Press, 1969).

* = data is not available.

Fig. 13 NUMBER OF FESTIVALS, 1961, IN SELECTED TALUKS, TAMIL NADU.

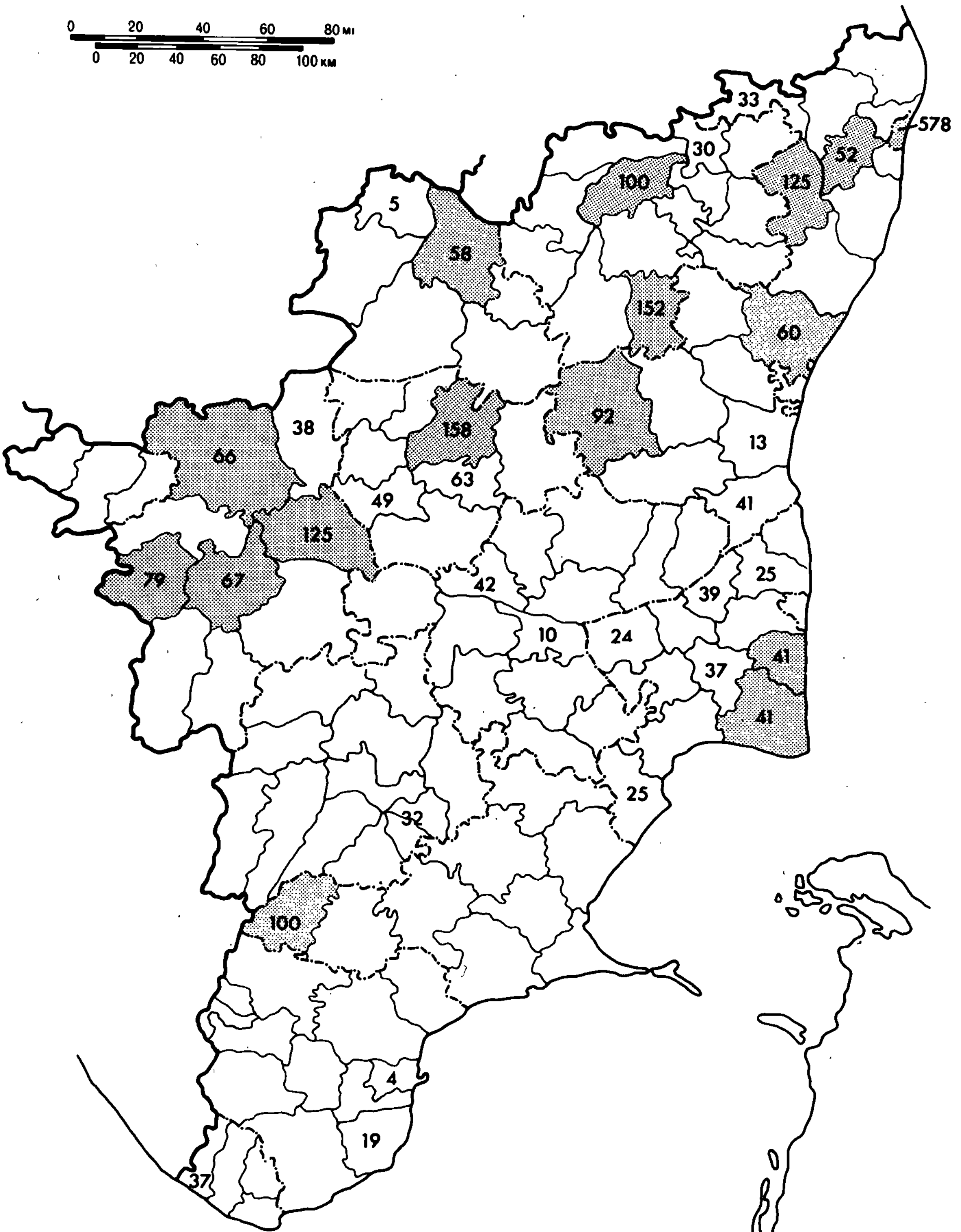
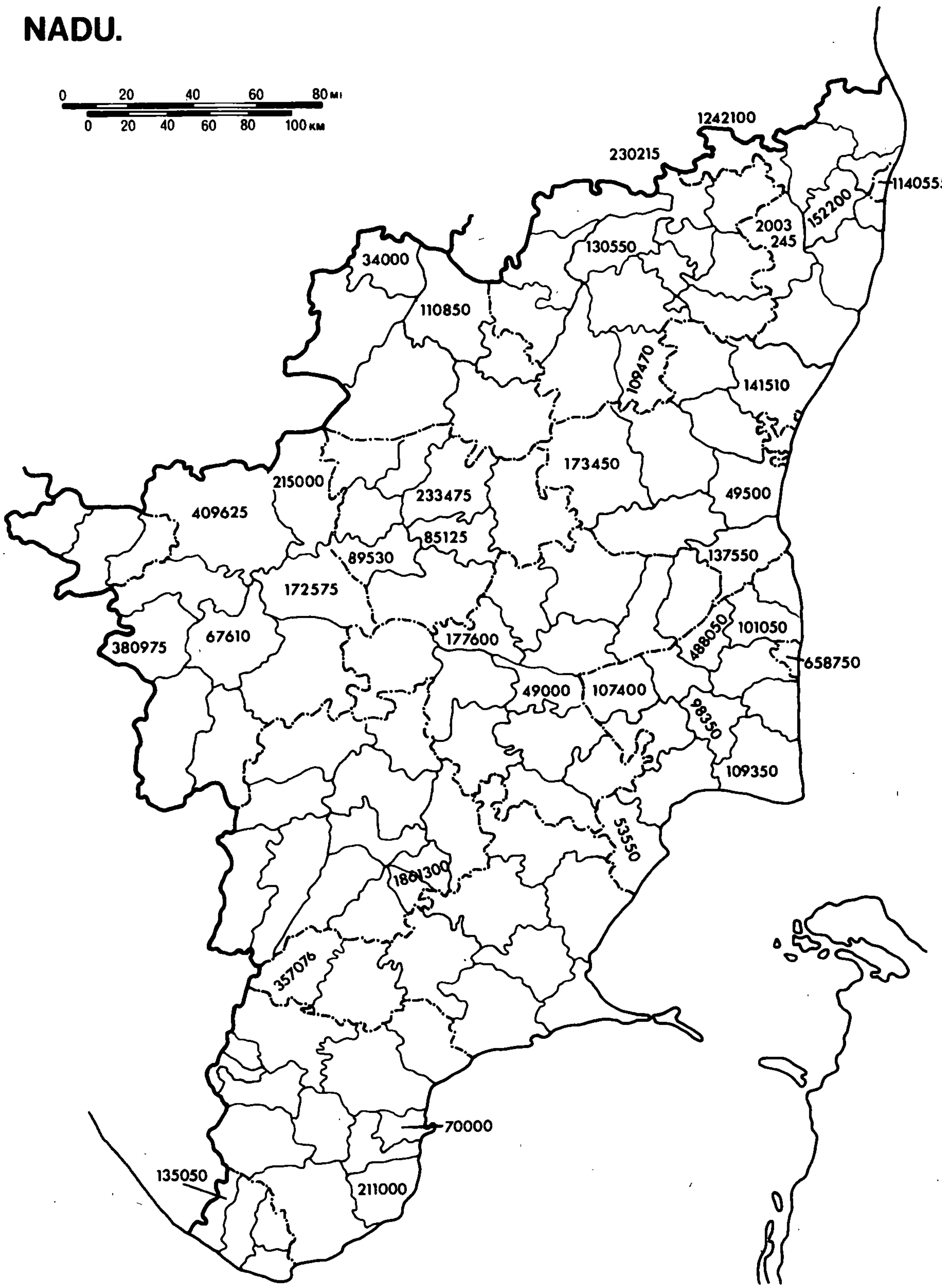


Fig.14 ESTIMATED NUMBER OF PEOPLE ATTENDING FESTIVALS, 1961, IN SELECTED TALUKS OF TAMIL NADU.



Compiled from : India, Census of India, 1961, Vol. IX, Madras : Fairs and Festivals, Part VII – B (Madras : Government Press, 1969).

present estimated number of festivals and people attending these festivals in selected taluks of Tamil Nadu.

It is not possible to correlate the degree of endemicity of each pilgrim center to number of attendance or festivals heald because so far no records of actual cholera incidence at the pilgrim centers during peak season could be found, or even obtained from the Public Health Department. Informal talks with Public Health officials did indicate a positive relationship in the years prior to 1961.

Preventive measures at festivals involved innoculating local people as well as pilgrims during the intensive campaigns in the 1956-60 period. At this time, compulsory innoculations were introduced upon entering major fairs and festivals and at different nodal points along the pilgrim routes. Many difficulties were encountered in attempting to set up an effective preventive program. Innoculation takes seven days to mature, which raised questions about innoculating at festival centers. Attempts were then made to innoculate local populations a month earlier, within a five mile radius. It was difficult to reach all visitors at festivals, even with prepared publicity. Most pilgrims were illiterate and unaware of the importance of public health sanitation and hygiene. Local points of entry were important to different degrees. Along coastal areas, where people arrived by boat, 65 percent to 70 percent coverage was possible. Roads were difficult to check, with only 25 to 30 percent coverage possible. Railway stations with two or three exits posed barriers to success, as did an uncooperative staff. Now innoculation measures have been decreased, and more attention is being paid to improving the environmental sanitation of these centers through the use of chlorine powders, installation of tube wells, latrines, etc.

However, this area of study needs further investigation and analysis before any conclusions can be presented. There is need for further research on this subject; no single factor can be held responsible for the growth and propagation of this disease.

Environmental Factors

Environmental factors must be considered such as the adequacy of protected water supplies, drainage and sewage facilities, environmental hygiene, susceptibles and their concentrations, and population movements. A West Bengal study observes that while the natural environment creates favourable conditions for the incidence of cholera, man's cultural environment helps its proliferation (Banerjee and Hazra, 1974, p. 107). Environmental readjustments are needed for effective control and prevention of endemic foci.

Rural Water Supply

Protected water supplies are non-existant in rural areas, and many water-borne diseases are prevalent. Rural populations depend upon the rivers, ponds, streams, tanks and wells for daily requirements. The surface water sources often become contaminated by infected persons, but in many rural areas people continue to draw water from these surface sources, in spite of the availability of safe water supplies from wells. There are places in the State where people utilize, for drinking purposes, the water available in stagnant rain water pools, mosquito-infested dirty tanks and wells, and other sources which are found hardly free from contamination. Even where protected water supply is available, it is not plentiful (Demography and Vital Statistics, p. 241). Good water supplies are needed for purposes other than drinking, such as washing clothes, dishes, cooking utensils, etc. These may also become vehicles of contamination and contagion if sufficient care has not been taken to provide a safe water supply for these purposes also.

At present, it is estimated that 4,916 villages in Tamil Nadu are without any source of water, 2,230 villages are found in endemic areas with no safe water supply, and 11,814 villages have inadequate water supplies, especially during summer (See Table 9). These people are continuing to use open, unprotected wells, step wells, ponds and rivers because facilities for disinfection and chemical treatment of water are limited. Rural population comprises about seventy percent of the total population of the State. The Health Report (1972) by the State Planning Commission confirms that water sources in many places remain infested with carriers of water-borne diseases. Most of this water is from open step wells and is chemically and bacteriologically substandard, but because of serious shortage, continues to be used for drinking (p. 16). Thus, controlled rural water supply is a high priority in long-range planning goals.

Urban Water Supply

In some instances, incidence and mortality of cholera rates have been found to be higher in urban areas than in rural villages. This may be due partially to the rapid growth of towns and cities, and the resulting

TABLE 9

WATER SUPPLY FACILITIES IN TAMIL NADU, 1970

	Total Number of Villages	Population
Total Number of Villages and Hamlets	58,995	
Villages with Populations less than 500	45,728	
Villages with Populations between 500 and 2,000	11,560	
Villages with Populations more than 2,000	1,707	
Villages with open wells as sources	43,913 (66,385 wells)	
Villages with bore wells as sources	4,200 (2,288 bore wells)	
Villages with piped water supply	1,877 (18,298 tube wells)	
No water supply source	4,916	3.8 million
Inadequate water sources	11,814	5.8 million
Drinking water available, but endemic disease is present	2,230	1.9 million

Per Capita Consumption (estimated): 2.2 gallons per day

Source: State Planning Commission, Government of Tamil Nadu, Rural Water Supply, unpublished report of the Working Group on Resources and Outlay of the Task Force on Rural Development, Madras, April, 1972.

partially to the rapid growth of towns and cities, and the resulting congregation of large numbers of lower socio-economic groups of migrants with poor health and sanitary disciplines; overcrowding, congestion and growth of slums are also contributory factors. In Tamil Nadu, during the census period 1961-71, the growth rate of the urban population has been found to be greater than the rural growth rate. However, in absolute figures, both the rural and the urban populations have increased considerably, hence their proportionate share of the total has remained the same. Any public health measures related to the provision of utilities should take this demographic factor into consideration. At present, fifty-eight percent (8.99 million people) of the aggregate population of 740 towns are served by protected water systems to varying degrees of adequacy (State Planning Commission, Health Report, 1972, p. 14). The State Census classifies 340 concentrations of population as urban, thus a protected, piped water supply in these urban areas is essential for the control of water-borne epidemic and endemic diseases.

The Problem of Environmental Hygiene and Sanitation in Urban and Rural Areas

Drainage

Drainage facilities in urban areas appear not to have progressed much, when compared to the overall water supply system. The entire urban population requiring underground drainage is presently estimated at 11 million, however, only twenty-four percent (3.75 million people) of the urban population are at present served by the underground drainage systems (State Planning Commission, Health Report, 1972, p. 15). In some municipal towns, the sewage system frequently serves only part of the area; even in large urban agglomerations, large numbers of dry earth latrines are not connected to the city sewers. Water supplies, drainage facilities, and sanitary waste disposals are closely related, and public officials encounter many barriers in attempting to develop measures to deal with them. The most pressing and immediate task is to provide sufficient drainage facilities in crowded and growing urban areas.

Rural Sanitation

The Task Force Report on Health states that all 58,595 villages with a total population of 28,656,265 (1971) still need a centralized system for the disposal of sullage and sewerage under Community Development Programs. It notes that septic tanks, leakage pits and organized sustenance drainage are still rarely found in these villages. The defacation habits of people in the open space, near the rivers, streams, and ponds and tanks are a well-known phenomena in the State (p. 17). Many intestinal diseases, like cholera, diarrhoea, dysentery are contacted, for example, when rain-water carries parasites from excreta into the rivers, streams, and, through seepage into the wells.

The shortage of garbage vehicles and poor arrangements for proper collection and enforcement of public health rules are some of the contributing factors for disease to develop and spread in towns. For example, the collection of human waste from household latrines is a common practice in many places. Transporting of these wastes to composte pits by human carriers and carts provides an environment for the spread of many infectious diseases. The problem of solid waste disposal also plagues the urban areas. Solid waste consists not only of human waste, but also organic and inorganic waste from households, hotels, markets, industries, street sweepings, dead animals, etc. Cows, dogs, goats and pigs provide a great menace to public health by freely using dust bins of the towns, scattering refuse and providing an ideal environment for the transmission of diseases (State Planning Commission, Health Report, 1972, p. 69).

It is interesting to analyze some of the observations made in the Census Report regarding the development of sanitary laws in the State (British India) since 1884, which make suitable provisions for the improvement of sanitation in the rural areas and in the municipal towns of the State (Demography and Vital Statistics, pp. 399-402). Initially (Local Boards Act, 1884) local self-governments (Panchayats) were given sufficient duties in dealing with the matters related to Public Health (e.g., cleaning the village streets, drains, tanks, wells and other public places, constructing and repairing tanks and wells, and to ensure provision of water for domestic use, etc.). Also, at this time, under the Madras Local Funds Act, 1871, a new revision provided for the improvement of village sites, water supply, for sanitary arrangements during fairs and festivals, for the scavenging of small towns and large villages, for the construction and repair of markets, slaughter houses, latrines, dust bins, and drains and other measures to facilitate the promotion of public activities. While municipal towns had separact acts of their own (Madras District Municipalities Act, 1884) Local Boards Act was found to be devoid of any powers by which public health, especially in enforcing precautions affecting infectious diseases, could be handled. Thus the "entire rural population was subject to no sanitary control beyond that which could be effected by persuasion" (Demography and Vital Statistics, p. 398). The Act was amended (1897) to include a number of sanitary rulings such as protection of water supplies, conservancy and combating infectious diseases. Many of these rulings were not enforced in action in the villages. As a result, sanitary arrangements continue to remain in rudimentary stages of public health development.

In the District Municipalities Act of 1884, it was noted that even though the powers conferred by the Act upon municipal authorities might have greatly improved the sanitation, few showed interest in carrying out the recommendations of inspecting officers. Failure to improve sanitation was usually attributed to lack of funds, and recommendations of inspecting officers were put aside until funding became available (p. 398). The plea, lack of funds, might have been described more accurately as lack of interest in the majority of cases. Public Health and Sanitation responsibilities were later (1908) transferred to the Taluk and District Boards from the local Self-Government under the new Local Boards Act (Act XIV of 1920), a result of lack of co-operation and practice from small local bodies in the districts.

There are sections related to the Public Health Measures and Rules in Madras State under various Acts: (1) The Madras City Municipal Act, 1919; (2) The Madras District Municipalities Act, 1920; (3) The Madras Local Boards Act, 1920; (4) The Madras Village Panchayat Act, 1923; (5) The Madras Town Planning Act, 1920; (6) The Madras Town Nuisance Act, 1889, with Amending Acts and Regulations; (7) The Indian Factories Act, 1911; (8)

Registration of Births and Deaths Act, 1899; (9) The Epidemic Diseases Act, 1897; (10) The Madras Prevention of Adulteration (Foods and Drugs) Act, 1918, and Amending Act, 1927; (11) Indian Penal Code (Nuisance and Adulteration of Foodstuffs); (12) The Code of Criminal Procedure; (13) The Indian Parts (Amendment) Act, 1911. For example, under the Madras Village Panchayat Act, 1920, "a Panchayat may exercise certain powers and perform certain duties concerned with public health, e.g., water supply, continuation of drains and disposal of drainage water and sewage cleaning, provision of latrines, registration of births and deaths, and enforcement of vaccination, etc." (Demography and Vital Statistics, p. 400). The enforcement of many of these rulings remain ineffective and their practical application is neglected either for want of funds or lack of initiative on the part of the local bodies as well as the Public Health Department. If applied, the Act and the bylaws would give tremendous scope for improving the rural and urban sanitation and health in the State. Until this stage is accomplished, public health hygiene and sanitation continue to experience a low level of growth in Development Planning in the State. This may have its own implication on the efforts at the control of epidemic and endemic diseases through environmental sanitation, which at present, continue to influence many disease incidence and spread in Tamil Nadu.

In this part, the characteristics of the agent, the host and the environment have been considered separately, though they are closely inter-related phenomena in disease incidence patterns, and illustrations of the relationship were given. However, the effect of one factor upon others is not always known. This is an aspect of medical geography or epidemiology which has been somewhat neglected or little studied. It is only with a sense of statistical reasoning and with certain assumptions about disease process that certain explanations could be offered in this study.

PART V

CHOLERA CONTROL, PREVENTION AND ERADICATION

The objective of this section is to present the cholera control activities, the difficulties and problems encountered in administration and implementation of cholera control programs in the State of Tamil Nadu. These activities have been initiated in a somewhat systematic manner only since 1971. Prevention and eradication of communicable diseases is one of the basic problems of health planning in developing countries. Public health programs differ from country to country, depending upon the priorities. Control of communicable diseases is one aspect of all public health activities.

Control and preventive measures related to communicable diseases involve both short-term and long-term programs. For example, mass campaigns are often initiated during epidemic situations, while long-term activities aim to provide basic facilities for health services. The assumption is that the incidence of the disease can be modified by intervening in the relationship between man and his environment; this is implicit in the concept of disease prevention. How can we influence the relationship between man and his environment to man's advantage? (Holland, 1970, p. 15). The balance between agent, host and environment may be altered in favour of the host in several ways: by destroying the agent or its reservoir; by interrupting its paths of spread; or by increasing host resistance (Miller, 1970, p. 20). There are several recognized ways in which cholera control programs are developed, by establishing a system of medical care, by effecting public health measures related to environmental hygiene and sanitation, and by educating the public. Surveillance activities also play a very important role in the control of communicable diseases. Some of these factors, including the administrative aspects of the health programs, and difficulties encountered in implementation in the State of Tamil Nadu are discussed below.

Cholera Control and Prevention Activities

Before 1969, cholera control activities centered around the immediate problems of prevention and control measures during epidemics. But in an endemic situation, where unconnected sporadic cases occur throughout the year, it is more a question of eradication. Since 1960, observations indicate that both case incidence and fatality rates were much lower than in previous epidemic years, even considering seasonal incidence patterns. In the earlier periods, it was found that the State experienced epidemic outbreaks which were believed to be imported; they exhibited rapid spread and high fatality rates. With the development of improved control measures and better health and medical services (a result of the Five Year Plans), infection has been decreased to a minimum. The problem of endemicity remains, appearing in different areas. As discussed earlier, a thorough knowledge and understanding of the causes of endemicity do not exist in the State. In spite of the vast amount of information available on the various aspects of cholera, no clear-cut programs have been initiated to identify and eradicate scattered endemic foci. Some of the measures of control and prevention are examined.

Control of Epidemics

When an epidemic breaks out, quick action is demanded of the nearest health personnel. Delays in action are noticed, due to late notification by village headmen to health inspectors. A health inspector is usually assigned to cover a population of 80,000 - 100,000 living in 100 - 200 villages distributed over an area of approximately 50 - 200 square miles. The disease may already have subsided or spread by the time medical personnel or inspectors arrive at the spot.

The measures described in the following paragraphs have now been adopted for prevention and control. Every water source is tested and chlorinated with bleaching powder or potassium permanganate. Some of the disinfectants are distributed to families; innoculations are done with anti-cholera vaccines, when available. The bleaching powder is found often ineffective, as a result of long exposure to air, in poorly covered drums. If a cholera worker reports an acute case, the inspector will obtain bacteriological tests. He is then prepared to take the necessary preventive measures. The cholera control workers, employed by the State Government, stay in each village or block and periodically chlorinate all the wells in the villages. The effectiveness of these measures depends upon the availability of chlorinating powder, and the care and regularity with which the workers perform their functions. Anti-cholera innoculation measures are usually carried out in each and every rural health center which has appropriate facilities; the effectiveness of this operation also depends upon the cooperation of the local population in visiting the rural health centers. Because the level of education is very low in rural areas, the success of this measure is quite limited to date. If medical personnel visit the locality during an outbreak, they may provide treatment with drugs and intravenous or a subcutaneous saline water, instead of the usual precautions that would be taken by the sanitary inspector. Very rarely do the medical personnel make an attempt to discover the source and the mode of spread of disease in order to deal with them effectively.

The shortage of staff often leads to the neglect of some villages, for instance, when more than one village becomes infected simultaneously in one season; this helps maintain a low level persistence. Some improvement has been observed with the growth of primary health centers. Two medical officers in each primary health center have a fixed tour program within their jurisdiction; i.e., once every 15 days they go around systematically to detect incidence. However, arrangements for sample-taking in cases of diarrhoea, bacteriological tests, and diagnosis for detecting cases on a large scale in the affected area remain poor, inconsistent and unorganized.

Health Care and Services

Health care is difficult to provide, because, often inaccurate statistics are compiled and it may not be known by authorities that assistance is required. Under-reporting is frequently noticed, especially in areas where cholera is not usually expected, in the pre-epidemic stages of suspected indigestion or a gastrointestinal upset. As compared to deaths, reporting of cases is poor and incomplete. As noted earlier, sources of data do not corroborate each other, and often the local health authorities or village headmen are reluctant to report cholera unless serious outbreaks or deaths occur. As previously stated, technical difficulties are also encountered in the detection of actual cholera cases. Clinically diagnosed cholera cases represent only a fraction of total notified cases. Because of low mortality, control measures have been somewhat relaxed. Thus, the public health officials believe now that the cholera somehow present, may not be in the classical acute form. Since 1970 and the improvement in health systems and laboratory facilities, more attention is being paid to collecting samples and performing bacteriological examinations. However, these are still not systematically investigated and detected. Diagnosis of samples is more or less confined to urban areas. Facilities and arrangements available in rural areas are far from satisfactory, except in some of the endemic areas specially selected under the cholera control programs. Even though relatively inexpensive techniques are available for control and treatment, accessibility of medical and health care systems to rural populations and their adaptive capacities to the facilities already available are still far below expected standards. Diagnostic facilities with the capability to confirm cases by laboratory methods are mainly in Madras City and the Madurai medical college at the present time. Only one medical research unit, the King Institute of Preventive Medicine in Madras City, has the capacity to carry out bacteriological and micro-biological testing. Catering to the needs of this State and to several other Indian States, the Institute supplies life-saving drugs like sera, vaccines, prophylactic cholera vaccines, etc. Confirmation of diagnoses by laboratory methods is necessary to enable the public health administration to obtain resources for the control of cholera. Public participation is necessary in order that prevention becomes an integral part of the health care program. Organizing health services in rural areas is an important aspect of communicable diseases' control activities. Health centers form the core of expanding activities related to communicable disease control programs. In 1969, special mobile epidemic control units were introduced in the State.

In the following paragraphs, some observations will be presented on the Health Service Units in the State and the difficulties encountered in their functions. The Task Force Report on Health (State Planning Commission, 1972) gives us the following information: there are 374 administrative blocks or panchayat Unions in the State of Tamil Nadu and the population of a block ranges from 80,000 to 100,000 people. The eventual aim is to locate at least one primary health center in each block ... Some may have more than one, some without any. There are 379 primary health centers in the 374 blocks. Table 10 presents the total number of primary health centers at the district levels. The number of health centers has increased; some have more than doubled during the decade 1961-1971, thereby indicating some progress in rural medical services in the districts. In 1950-51 it is reported that there were only 9 primary health centers in the State and this has increased to 123 (in 1961), a total of 379 in 1971. The Five Year Plans have caused their expansion. The primary health center located in each block is the principal base from which "Operation Health" (as it is referred to) is directed. It is generally composed of two wings, each with a medical officer (male or female), a health visitor, an auxiliary nurse, mid-wife and a health inspector. In addition, the main

TABLE 10

NUMBER OF PRIMARY HEALTH CENTERS BY DISTRICTS, TAMIL NADU, 1961 AND 1971

District	1961 Total Rural Population	1961 Number of Primary Health Centers	1971 Total Rural Population	1971 Number of Primary Health Centers
Chingleput	1,740,734	10	1,884,558	27
North Arcot	2,515,101	10	2,957,051	38
South Arcot	2,655,651	11	3,094,054	34
Dharmapuri	1,239,004		1,530,328	16
Salem	1,947,756	9	2,191,919	33
Coimbatore	2,525,302	20	2,804,162	45
Nilgiris	229,441	3	248,806	4
Madurai	2,195,482	14	2,608,945	35
Tiruchirapalli	2,512,007	8	2,984,861	31
Thanjavur	2,584,407	14	3,044,645	44
Ramanathapuram	1,822,307	11	2,111,833	32
Tirunelveli	1,382,397	8	2,166,216	31
Kanyakumari	846,836	5	1,023,887	9
Tamil Nadu/State Total	24,696,425	123	28,656,265	379

Source: (1) Statistical Division, Directorate of Public Health Services and Family Planning, Tamil Nadu.

(2) India, Census of India, 1971, Series, 19, Tamil Nadu: General Population Tables, Part II-A (Madras: Government of Madras Press, 1973), pp.

wing has a pharmacist, a male nursing assistant and a driver for manning the jeep in which the medical practitioner makes his rounds or attends to an emergency case.

Sub-centers, each serving a population of 10,000 persons, are attached to every primary health center. Every block, with an average population of 80,000, is served by eight sub-centers of which three are State sub-centers and the remaining five or more belong to the Government of India (State Planning Commission, Health Report, 1972, p. 6). Specifically set up under the Central Family Planning Program, the sub-centers continue to receive high priority in services and facilities given for this purpose. A sub-center normally employs an auxiliary nurse, or mid-wife and an ayah (maid), and is located on land donated by local people.

The Task Force Report on Health observes "in actual working the ideal is always less than true" (p. 6.). Administrative difficulties are sometimes encountered. Even though medical officers are scheduled to visit sub-centers two or three times a week, they rarely do so, because the driver is absent or the jeep is out of commission. Doctors are overworked, even under normal conditions, and find it difficult to handle emergencies and epidemic situations. The rudimentary nature of the facilities allow for a small amount of work to be accomplished; "More complicated cases, requiring specialized or extended attention, are referred to the taluk and the district headquarters hospitals (p. 7). The Health Report observes, "there are six to eight taluk headquarters hospitals in each district yielding a total of 86 taluk hospitals. Each hospital has an out-patient block with an average daily attendance of about 300 patients, and an in-patient block with a bed strength of 30 to 90. It is staffed with a minimum of two medical officers (one male and one female) and nursing and para-medical staff, varying in its real capacity for relief and cure according to the number of beds. The principal departments are medicine, surgery and mid-wifery with an operating theatre and facilities for post-mortems... The taluk hospitals are restricted in their functioning to curative work; in the quality of their services by the insufficiency of their strength and absence of specialities. The lack of adequate medical staff together with absence of transport renders the servicing of the primary health centers by these hospitals well nigh impossible" (p. 7).

At the next higher level, there are 13 district headquarters hospitals, each containing an out-patient block with an average daily attendance of 1,000 patients; 150 to 500 beds for in-patients (p. 7). Its staff contains eight to nine medical officers headed by the district medical officer. It also contains five to six specialities as well as staffed laboratory and x-ray facilities to aid diagnosis. The Task Force Report on Health states "The problems faced by the district headquarters hospitals are manifold. The district medical officer is charged with exacting clinical functions; he is besides responsible administratively for all the medical institutions in the district except the primary health centers. He is now unable to do justice to his work - either to his medical function of supervision or to the quasi-administrative duty of inspecting and providing leadership to the taluk hospitals. The public health work is looked after by one officer, the family planning work by another and the medical work by a third making integration of these services difficult. Lack of specialities and facilities for preventive care, of diagnostic facilities, of medical personnel with post-graduate degrees and the limitations imposed by low bed-strength have all detracted from the optimal use of these institutions in servicing the district population" (p. 7).

The progress achieved in health services by various districts, taluks and blocks varies from place to place, depending upon local initiative and participation in health programs. Considering the base population to be served by existing health centers, the primary level of health care still has a long way to go to achieve its goal.

After 1969, a cholera combat team was introduced in the major endemic district of Thanjavur; it is provided with an ambulance and the drugs and disinfectants to carry out preventive and control measures. Orientation training courses were conducted in Madras Medical College for medical and public health officers.

In 1972, a cholera control program which was centrally sponsored (with one hundred percent subsidy) was first introduced in the State. The program consists of the following: (1) a cell at headquarters; (2) one mobile medical unit at Tiruchirapalli district with a staff of 162 special cholera workers and six supervisors. It is now functioning in 75 blocks of the four endemic districts (as defined by the health authorities) of North Arcot, South Arcot, Tiruchirapalli and Coimbatore. This amounts to only covering half the number of blocks in each district. It is hoped to extend the system to the remaining fifty percent of each block soon. Now there are seven mobile epidemic control units in the State, three epidemic control units and a cholera combat team in the districts of Thanjavur, North Arcot and Tiruchirapalli. An additional team is expected to be introduced during 1975-76 in the endemic district of South Arcot. The major function of this team will be to perform innoculations as precautionary measures during the seasons of fairs and festivals and to develop surveillance activities. For example, in 1972, 1,469,731 innoculations were performed by the existing team, in 1973, 1,430,616, and in 1974, 1,725,434. In 1975, up to February, 865,221 people were innoculated. A mobile team has certain advantages, for instance, when explosive outbreaks occur in the rural areas which often exceed the existing treatment capacity of local personnel and facilities, the team assists in prevention activities such as disinfecting the houses of patients, supervising those contact cases, etc. Team members can also assist in maintaining the health of the community by arranging for the safe disposal of excreta and dead bodies, providing a safe water supply, carrying out innoculations and by promoting health education and information about the spread of cholera. The mobile team is also developing facilities for locally detecting and diagnosing any incidence of dehydrating diarrhoea and gastroenteritis, as incubation periods of these infections are of limited duration. This is to ensure that the infection caused by vibrio cholera is reported as cholera. The convalescent carrier state may persist in a few persons for 2-3 weeks although the period of excretion of vibrios by the contact carriers is short, possibly 5 days to two weeks. Since 1964, the El Tor biotype has given rise to new problems requiring new approaches. Where there are no laboratory facilities, staff, or skills available, incidence of cholera is often missed, confused or not reported. As W.H.O. states, "Epidemiological studies on cholera are most effectively performed when facilities are available for bacteriological characterization of the infected organisms isolated from patients and their environments. Such information, which will assist in the actual chain of transmission is obtained only if there is well organized and properly functioning health laboratory service" (W.H.O., 1970, p.130). "Since such services enable the causes and trends of epidemics to be studied, they constitute an essential element of public health measures for the control of cholera" (W.H.O., 1967b, p. 7). Even though there is a central laboratory service available for the State, the establishment of local laboratories is essential for effective operation of such programs. Public health officials should also be encouraged to keep themselves informed regularly of laboratory findings. "Otherwise if cholera does appear, it will be recognized clinically only after widespread dissemination has taken place, rather than by the detection of vibrio cholerae in the first case of overt clinical disease" (W.H.O., 1967b, p. 7). Services for sample collection, regional laboratories, methods of detecting vibrios in the environment, particularly in sewage, night soil and water, have not been found systematically developed or organized in this study area.

Control of Cholera through Vaccines

It was seen in Part III that the incidence of cholera in the State has declined considerably since the last decade (1960-1970). It was found that there were only 20 deaths reported in 1960, as against 26,432 in 1950. Since 1950 (see Table 11), anti-cholera innoculations have been carried out in the areas affected, as well as in the neighboring regions, and the infection was effectively brought under control. As we have seen this program still forms a part of cholera control planning in the State. District figures were not available for the later periods other than those shown in Table 11. The immunity conferred by the vaccination is very short, estimated to last between 3 to 9 months; in other words, it may offer one individual protection for one cholera season in the State. Hence, innoculation campaigns are organized just prior to, or during, the period when the outbreak is usually expected to occur. In 1961, the innoculation rate was reported to be at a rate of 9.3 per 1,000 population. This is low, considering its short immunity period. With the introduction of the El Tor type in the State, innoculation measures have not improved because the effect of the previous vaccine on this new type vibrae has not yet been confirmed. In the earlier period, vaccination prior to departing for a fair or festival was made compulsory. This met with limited success because of the large population coverage required and the limited resources available in terms of health personnel and services. However, the pilgrim centers have recently shown evidence of not being the foci of dissemination of infections. Low participation and resistence by the public were also evident. However, innoculations do help in reducing the susceptibility of the latent organism, thereby controlling the outbreak and spread to some extent, especially in season.

TABLE 11

INNOCULATIONS AGAINST CHOLERA BY DISTRICTS, TAMIL NADU, 1956-1961

District	Number of innoculations given in					
	1956	1957	1958	1959	1960	1961
Madras	47,385	286,500	26,928	21,893	7,648	4,666
Chingleput	69	12,689	3,061	10,120	2,126	6,176
North Arcot	10,043	107,547	120,660	70,616	112,998	31,688
South Arcot	4,067	21,416	206,615	16,306	23,686	31,190
Salem	5,150	82,299	182,023	12,038	23,500	42,769
Coimbatore	133,188	188,944	286,797	102,720	90,556	36,180
Nilgiris	706	406	221	1,873	438	396
Madurai	7,729	265,467	639,005	85,846	85,620	14,161
Tiruchirapalli	185,733	436,720	68,930	26,181	15,237	108,096
Thanjavur	29,489	481,010	434,447	17,987	75,207	198,719
Ramanathapuram	47,375	12,873	116,149	9,491	46,466	15,590
Tirunelveli	11,208	218,562	209,009	12,839	13,600	6,935
Kanyakumari	262	2,456	9,797	1,037	10,821	5,976
State Totals	482,404	2,116,889	2,303,642	389,115	507,903	502,542

Source: India, Census of India, 1961, Vol. IX, Madras: Demography and Vital Statistics (Report), Part I-B9i) (Madras, Government of Madras Press, 1965), p. 260.

According to W.H.O., during epidemics, populations bordering the infected territories, areas with poor sanitation, the coastal zones, nodal points, travellers and customs officials, should be vaccinated. In endemic districts, vulnerable sections which are already known from previous experience should be given priority (Raska, W.H.O., 1970, p. 111).

Immunization provides considerable protection, at least for the short period of effectiveness, but it is difficult to prevent the occurrence of the disease by this method without yearly revaccination of susceptibles. And this process is difficult to achieve administratively without public participation.

Vaccine studies are also being advanced by W.H.O. as one measure of effective cholera control. Anti-cholera vaccine is the only specific prophylactic available to deal with cholera epidemics. The current W.H.O. research involves "(a) improving anti-bacterial vaccines, including development of purified antigens, (b) evaluating anti-toxic immunity, (c) evaluating oral killed vaccines, (d) developing and evaluating oral live vaccines, (e) evaluating animal models in the immuniological agents, (f) investigating the routes of immunization and appropriate dosages, dose schedules and intervals between doses" (W.H.O., 1967b, p. 26).

Treatment of Cholera

There has been no difficulty in the present treatment of cholera cases in the State, especially with the mild El Tor variety; reported deaths have declined considerably. The treatment consists of effective rehydration fluids and antibiotics. However, the relative values of various antibiotics has not yet been fully defined. W.H.O. states that the search for new specific treatment and adaptations of treatment procedures to field conditions deserves further attention. The development of simple techniques for the preparation of rehydration fluids in the field is still awaited. In the event of a really large outbreak in those rural areas with rudimentary health facilities, treatment would be difficult. It would be hampered by lack of spaces for isolating and treating cholera patients, lack of facilities for the transfusion of large quantities of electolyte solutions, the regulation of the state of hydration and the amount of nursing required. To some extent, the recent introduction of mobile epidemic control units was expected to provide such arrangements. Their capacity is, however, limited for dealing with large outbreaks if they occur simultaneously in different places.

The Need for the Surveillance of Cholera

The introduction of epidemiological units in regional territories is a first step towards the development of a surveillance system. Surveillance of the population will help recognize early signs of outbreak by detecting the presence of cholera in the community. The distribution of communicable diseases never remains fixed due to continual changes in the behaviour of the agent, environmental circumstances and population immunity. Changes are often difficult to detect, and without surveillance, may pass unnoticed and therefore unchecked in their earliest stages (Miller, 1970, p. 23). Surveillance includes a wide range of activities (Raska, p. 114): locating all suspected cases; laboratory investigation of all cases of diarrhoea; instructing medical personnel in diagnosis, treatment, control means and epidemiology; offering training courses (for clinicians, microbiologists, sanitary engineers, epidemiologists, health workers and mobile teams); establishing communication and transportation facilities; isolating and hospitalizing patients; and effecting emergency treatment and control measures (rehydration fluids, antibiotics, disinfection and vaccination). It also involves the continuous collection and analysis of mortality and morbidity statistics, as well as the other relevant environmental data such as bacteriological safety of food and water supplies, vaccination records, dissemination of information to those responsible for disease control.

All this requires planned organization and intensive investigation and should provide a scientific basis for advising on control measures and planning health services related to them. Success is based on the process of organizing investigations and taking suitable action. Clinical and laboratory investigations should be fed back and co-ordinated with activities of public health workers and the community. In this study area, surveillance activities have been established and the Public Health Department is responsible for implementing them. But they are not strictly enforced at present, nor do they have fully developed networks; the operation is evidently piecemeal. A well-integrated surveillance system should be linked with national and international surveillance activities. To stop the recurrence of cholera, a continuous program of surveillance is necessary.

Where importation of cases from outside of the State is suspected, exchange of epidemic intelligence between neighbouring States is essential. Even though the Public Health Department reports that such exchanges exist, so far only periodic and infrequent reports are available. There is no Central control of epidemic diseases in India which makes it difficult to carry on an efficient intelligence exchange between the States.

Environmental Measures in the Prevention of Cholera in the State

Provision of Safe Water Supply for Urban and Rural Areas

The Health Report (State Planning Commission, p. 64) claims that over seventy percent of all urban areas in the State have been provided with a protected piped water supply. The remaining 565 towns, six townships and four municipalities, with a total population of 5.65 million, will be covered by programs scheduled for completion by 1977. When completed, the Fifth Plan (1971-1975) will provide water supplies for 4,916 villages which have no water supply source, for 2,330 villages in the endemic areas, and for 11,814 villages in rural areas which have inadequate water supplies (p. 4). Purification of rural water supply for safe drinking is to be undertaken during the perspective planning period (1972-1984). The Fifth Plan will also provide underground drainage facilities for the 722 urban towns yet unserved (p. 4). Sanitation disposal programs are still lagging; construction of sanitary latrines together with a leach or soaking pit for the entire rural community, is also to be completed during the twelve-year period. The Poonamallee

Public Health Research Institute, in Madras City, has devised an economical water seal latrine with a leach-pit to be used for final disposal. Work is advancing as a pilot project in four selected districts as part of an experimental-cum-action program (p. 17).

The environmental sanitation is planned to be entrusted to the Community Development Department of the State Government. It is proposed by the Task Force Report on Health that every district should have a workshop under the control of the public health engineer for the manufacture of latrines, using local resources. It is hoped, by this method, to integrate the community into the development of the rural sanitation program and generate public co-operation and participation necessary for progress.

A total of 58,595 rural villages still await a centralized system of disposal of sullage and sewerage (p. 17). Previous organization of rural water supplies in Tamil Nadu was based on the extension of local facilities already in use. Scattered benefits were felt only by combining the efforts of many agencies, created over the five-year plan periods. Several agencies were created for the purpose of ensuring the operational effectiveness so that very limited resources would reach widespread areas in a way that is both geographically and technically balanced (State Planning Commission, p. 16). At present, for a rural population of 28,656,265, there are 3,447 overhead tanks, 22,238 hard pumps, and 60,049 draw wells in Tamil Nadu, with many needing to be upgraded.

A Water Management unit, under the Water Supply and Drainage Board, was created in 1971 to deal with water as a single, state-wide resource and prepare legislation for its conservation and equitable distribution (State Planning Commission, p. 4). It will also execute a program of urban and rural water supply in the State. Some recent activities of the Tamil Nadu Water Supply and Drainage Board center around installing power pumps and bore wells in endemic areas where draw wells are in existence (Table 9). A UNICEF program which successfully provided deep bore wells in selected water-scarcity villages in the districts of Dharmapuri, Salem, Coimbatore and Madurai, gave initiative to the State government to follow up the program by reaching even more villages in the State. Since these programs were begun during 1972-73, it is too early to judge their success or failure.

Endemic Areas and Rural Water Supply

Because cholera is often considered a water-borne disease, most governments provide a safe, protected drinking water supply for its inhabitants in areas where the disease is prevalent. The Tamil Nadu Water Supply and Drainage Board is entrusted with the responsibility of implementing plans for water supply systems in the endemic areas covering 2,230 villages in the State within a period of two years (1974-76). For this purpose, a list of villages have been selected in each of the districts. Table 12 shows the total number of endemic villages identified in each district and the number of villages for which certain details are still to be collected. Figure 15 shows the location of such villages in

TABLE 12

NUMBER OF ENDEMIC VILLAGES TO BE COVERED

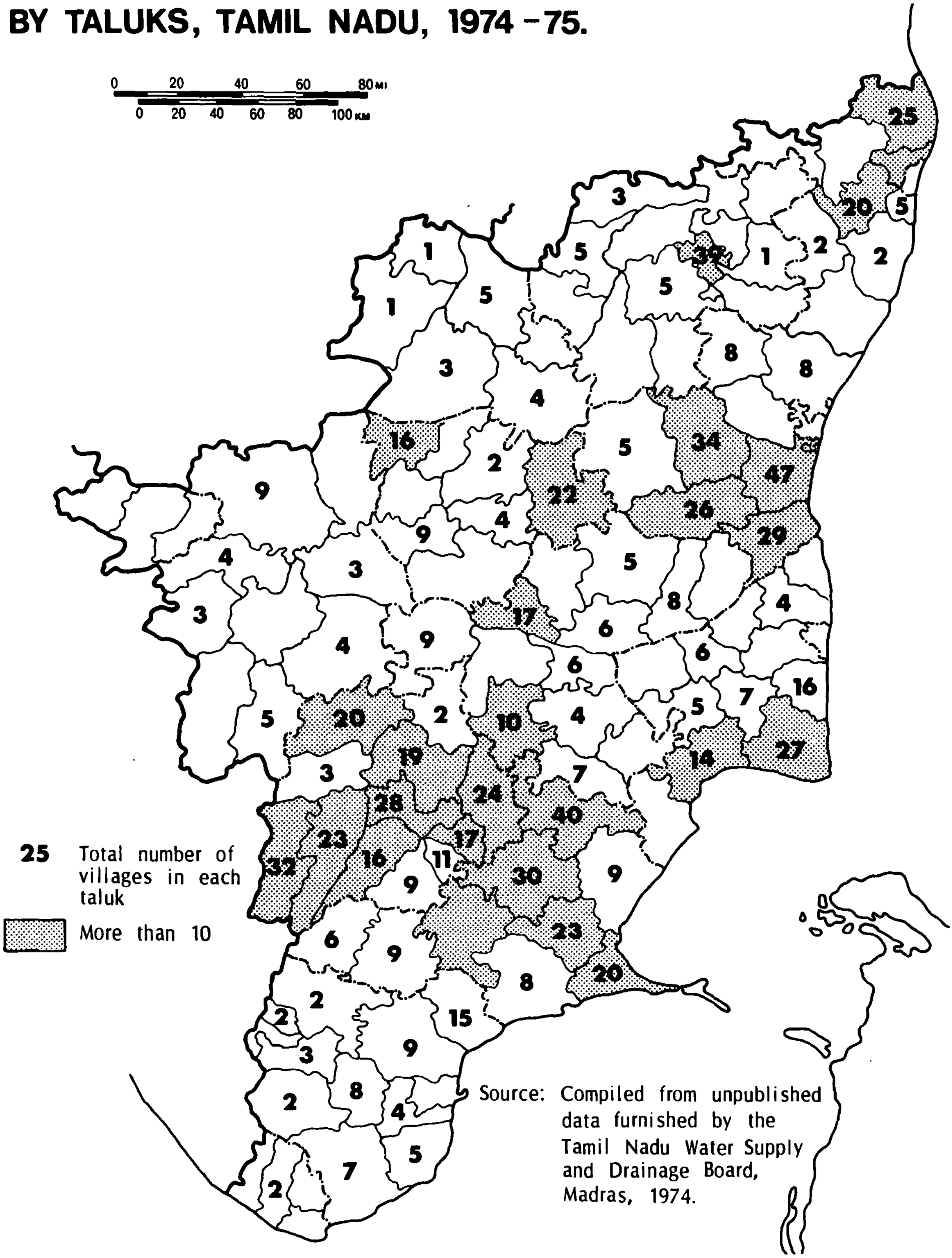
BY

RURAL WATER SUPPLY SCHEMES BY DISTRICTS, TAMIL NADU, 1974-1975

Name of District	Total Number of Endemic Villages Selected for the year 1974	List of Villages Yet to be Covered	Number of Endemic Villages for which Names are not Available	Number of Cholera Affected Villages Identified
Chingleput	59	57	20	18
North Arcot	53	29	26	97
South Arcot	167	60	75	209
Dharmapuri	22	12	5	72
Salem	52	49	7	4
Coimbatore	34	42	3	7
Madurai	204	60	99	5
Tiruchirapalli and Pudukottai	105	61	37	NA
Thanjavur	79	60	12	NA
Ramanathapuram	209	60	48	115
Tirunelveli	55	59	27	11
Kanyakumari	2		2	4
	1,041		361	542

Source: Unpublished data furnished by Tamil Nadu Water Supply and Drainage Board, Madras, 1974.

Fig.15 TOTAL NUMBER OF ENDEMIC VILLAGES SELECTED FOR RURAL WATER SUPPLY PROGRAMES, BY TALUKS, TAMIL NADU, 1974 – 75.



Source: Compiled from unpublished data furnished by the Tamil Nadu Water Supply and Drainage Board, Madras, 1974.

different taluks of Tamil Nadu. A large concentration is found in the districts of Ramanathapuram, Madurai, South Arcot, North Arcot, and Tiruchirapalli respectively.

An equitable distribution of protected water supply in endemic villages in all development blocks is sought. In the first phase of the program (1974-75), 1,041 villages are expected to be covered (Table 12). The details of name and population of 361 out of 1,041 villages are not yet furnished. Therefore, only 680 villages are considered for development in 1974-75. Those endemic villages which are already covered by other programs sponsored by UNICEF are excluded from the list shown in Table 12.

Villages with less than 500 population are expected to be provided with hand pumps. Villages with population between 500 and 2,000 will receive a well or deep bore well and those with population 2,000 and more will get deep bores and bore wells, and wherever possible, ground water reservoirs. Energizing wells depends on the availability of both water supply and electricity. In endemic areas, it is necessary to provide a centralized protected supply to prevent contamination. In rural areas, street distribution is not possible. Villages with populations above 2,000 are thus expected to be provided with overhead storage tanks. In the plans, drinking water needs of communities are given preference over agricultural use. Personnel and equipment for these plans are still limited and are not expected to meet demands for the next two year period.

Long-term measures such as environmental sanitation, water and food control, and sewage disposal are very effective, but cannot be applied immediately on a large scale owing to financial limitations. An extensive control, surveillance, and eradication program would not only require international assistance, but also efficient organization on the part of concerned public health authorities in terms of allocation of resources, manpower, and time. The present preventive measures of cholera, though improved, are still found to be ineffective and cannot achieve its desired control and eradication as evidenced by continued occurrences of cases with low intensity in Tamil Nadu. The development of simple and practical devices for the disinfection of water, food, and wastes under field conditions deserves further investigation, research and action.

The provision of safe water supplies by means of protected wells in the rural areas and improvement of purification methods in urban and semi-urban towns has always been much discussed and reported. But the achievements of such plans have been unsatisfactory. Paucity of funds due to priority of other emergency needs have given rise to only stop-gap measures of dealing with the disease. Unless environmental sanitation defects are removed, the hope for eradication or even effective control of cholera and other water-borne diseases will be remote. Even though the disease appears to have lost its intensity or declined in incidence, the environmental conditions favourable for its recurrence still exist in almost all areas of Tamil Nadu.

Public Health Education and Control of Communicable Diseases

Health problems are generally handled through medical care, environmental measures and health education. It is a well-known phenomenon that low standards of personal hygiene, unsanitary habits and customs can lead to ill health. The control of diseases like cholera requires a reduction in contact between the causative agent and the host. This could be achieved through improving environmental sanitation, but also by improving the social environment in which people live. Examples of improvement which would be effective are: boiling all drinking water obtained from rivers, ponds, unprotected wells in every village and hamlet, particularly those located on the banks of rivers; implementing better food hygiene methods, such as hand washing after defecation; controlling house flies; proper disposal of human and animal wastes; burning of all infective materials from patients suffering from infectious diseases, etc. (Brockington, 1971, p. 7).

In areas of low literacy level, ignorance of the scientific bases of health and modern concepts of the biology of infection together with deeply rooted customs and beliefs creates barriers to the development of public health networks. Even the best sanitary installation and public health measures remain ineffective when they are not accepted by everybody or properly employed, or accompanied by suitable personal hygiene (W.H.O. Chronicle, 1966). Infectious diseases control depends on the status of the public understanding, acceptance and participation in public health programs. Objectives of health education techniques should be to deal with all aspects of common health problems in a community. For example, in the control of cholera the most effective techniques should be used to educate the people in the prevention of enteric disease on a permanent basis. When cholera appears or thereafter to recur, a properly educated community should be in a position to take all preventive measures related to food, water, clothing, waste disposal, etc. Education should also be directed to the proper utilization of facilities (such as sewerage, drainage) already in existence, especially in urban areas. Instructions in the principles of hygiene and sanitation in rural areas is usually expected to be provided by health workers, clinics and health centers, school teachers in adult education centers. The existing indigenous beliefs, habits and customs should be well understood in designing the program of education. Large-scale forceful development schemes imposed on a population from outside have often failed in the past (Davey and Wilson, 1970, p. 14). This failure may be due to not considering local values.

Unless development schemes are broadly based and cover all important aspects of human activity, they tend to lead to unbalanced programs and create fresh problems. For example, if disease control outstrips advances in education and in economic standards, the rapid increase in population that almost always results may over-strain the country's resources for food, housing and employment opportunities (Davey and Wilson, 1970, pp. 3-5). It should also be emphasized that the control of communicable diseases depends upon the state of enlightenment of the inhabitants, firstly at the political level in granting power to carry out necessary measures, and then at the level of the individual who must be educated in health matters in order that he will avail himself of the facilities provided (Ian Taylor, 1970, p. 270).

As far as the status of health education in the rural areas of Tamil Nadu is concerned, it was found to be in a very rudimentary stage. Urban areas are no better in many aspects related to public health. As we saw earlier, little change, if any, is noticed in terms of improvements of environmental sanitation of rural settlements scattered over the landscape. For example, during outbreaks of infectious diseases, the protection of public health depend very much on the public's awareness, acceptance and participation. Mass media techniques in communication (pictures, illustration, talks, films) are used only during epidemics and at certain seasons of the year when big fairs, exhibitions and festivals are held. A public health booth is created to inform the public of the dangers of infectious diseases. No systematic approach to a continuing education on communicable diseases is in evidence. Thus, sustained measures for total eradication have not been found to be undertaken when once the epidemic shows signs of dying out in any place or an area.

Lately, priority in health education has been given to family planning and nutrition. Other aspects, such as environmental hygiene and sanitation receive low priority. In the rural areas, even though primary health centers and their staff are expected to promote health education, the subject still receives last priority in their activities. A primary health center deals with works on medical care, vital statistics, family planning, sanitation and health education.

On the basis of experimental methods in health education programs in operation in selected areas in Tamil Nadu, the following information was obtained by field enquiries and interviews with officials and workers in the Health Education Department. No other information was available on this subject from other sources.

Three methods adopted to impart health education to rural villages in the State center around mass, group and individual approaches. The basic problem involves first gaining access to a community and assessing its health needs and problems, habits, customs and beliefs. Mobilization of a community is needed to provide proper education and control, but this is not an easy task. Several criteria have to be taken into account: caste system, population characteristics, social system as a whole (religious belief, social habits), leadership patterns, existing village institutions, if any, occupations, political situation, amenities available, educational facilities and sources of income. Adaptive capacities for designing a program of health education is based on gaining information on knowledge, poverty and environmental conditions of an area. This information is normally gained through contacts with popular leaders (formal and informal), school teachers, post-masters, and leaders of the community, and involving them in the process of influencing and developing self-help schemes through co-operative efforts of the villagers themselves. The leaders, busy with their own activities, are now beginning to show some interest in health education related to environmental hygiene and sanitation. The gaining of their acceptance and approval is a significant factor. In view of this, a slogan, "know your people and know your area" is promoted to encourage people's involvement and participation in public health measures for the prevention of diseases.

Mass media type of communication through publicity (i.e., the use of newspapers, public lectures, radio, and film shows) is a one-way street, creating awareness, but with no direct communication for checking feedback, as to whether individuals actually practice what they have heard.

Approaching individuals is an on-going method; but it is too time-consuming and questionably effective. In rural areas, behavior change or attitude change are communicated most effectively by using group techniques. Through group discussions, it was found, for example, that the ill-effects of not having been vaccinated could be learned in less time than through contact with individuals. Personal experiences of the group members are shared. Open discussion and feedback add to existing knowledge. Decision-making is also found more effective in the group approach.

Resistance is always encountered, even at the group level. People are interested in their well-being, but they need frequent exposure to therapeutic health habits by regular participation in the group. Individual and group approaches are found to be best suited for improvement of the environmental sanitary conditions. Disease prevention methods are still slow in developing.

Poor participation by the people is partly due to the very fact that the primary health centers and sub-centers whose function is to impart health care systems to the villages, are often located far away from the main village, thereby creating an alienating impression in the community. Services must reach people who are miles away. Facilities for the training of health personnel are meagre. Diplomas in health education are presently being awarded by a voluntary educational institute, the Gandhigram Institute of Rural Health and Family Planning in the Madurai district. It offers training courses for sanitary inspectors and family planning staffs. However, the capacity of the Institute is limited to thirty people a year.

There are very few health educators in government health services; social workers are rare in rural areas. Expected high standards have not yet been attained in the community development programs. Even though teachers' training institutes give brief training in nutrition and health for teachers in rural areas, attempts at incorporating principles of health education in the syllabus for pahchayat or primary schools are far from succeeding.

It is hoped that an improvement in health education will stem from the overall plans for strengthening basic health services in the State. The malaria control program is a good example of what could be done with cholera. According to the Task Force Report on Health, the Government of India recommends to the State governments that they strengthen the basic health services in the malaria "maintenacne phase area". This plan, if augmented according to the following staff pattern, would be eligible for full government assistance (State Planning Commission, p. 26): (1) one basic health worker per 1,000 population; (2) one health inspector for every four basic health workers (i.e., two health inspectors per block or primary health center); (3) one laboratory technician at every primary health center for conducting microscopical examination. The duties and functions to be performed by the basic health worker would include: (a) malaria vigilance; (b) health intelligence, viz. (1) recognizing and reporting of major communicable diseases including cholera; (2) recognizing and reporting of patients with chronic cough, continuous fever; (3) compiling vital statistics of births and deaths; (4) smallpox vaccination; (5) health education in relation to this work; (6) the provision of counselling and information bearing on family planning. The Report estimates that " as against 3,199 sanctioned posts of basic health workers and 488 basic health inspectors in the State, the requirements population-wise are 3,240 and 810 respectively, inclusive of an additional complement of 250 health inspectors" (p. 26). It recommends appointing one basic health worker for every 20,000 of the urban population (p. 26).

The development of health care systems is determined by many factors, the most important being technical availability to cope with various kinds of health problems and the potential resources for public health programs allocated in relation to priorities given for other sectors of a planned economy. Planning of health services and health teams may be classified as political, historical, cultural, economic, demographic, geographic, epidemiologic, scientific and technological

(Forewell and Brotherston, 1971, p. 397). For example, at political levels it is determined by different levels of priority given, at cultural levels it involves public demand for medical care and change in public attitudes. Forewell and Brotherston believe that the assessment of priorities is a difficult exercise being conducted by a series of informal guesses and value judgements. For example, in the study area, even though much effort and resources were spent in communicable disease control and malaria eradication in the fifties and early sixties, a significant decline in incidence has resulted in slackening of these measures; resources and personnel priorities are now directed towards family planning programs. But the long-term process of eradication of infections is not yet complete. Continuity in building up surveillance activities must be an essential component of the Health Plans as the danger of the recurrence of diseases like cholera still remains in the study area.

PART VI

SUMMARY

This study examined the extent of reappearance or re-establishment of cholera in areas from which it had apparently disappeared or declined some years ago. The geographic distribution of cholera in one such area, the State of Tamil Nadu in India is studied with reference to the problem of endemicity and epidemiology during the period 1961-1974. Such studies are important in planning for the health care of a State.

Cholera is endemic in certain parts of India, where it is present throughout the year. It generally is found to occur in epidemic waves at intervals of about six to seven years. Some of the States in India possess significant endemic foci. Tamil Nadu ranked seventh among the nine States in India reporting higher average annual attack rates per 100,000 population in the period 1956-1966. Cholera was found never to be absent from the study area even though an obvious decline in mortality and incidence was noted. One of the problems of cholera is its endemicity. Endemic foci must be identified, located, and removed because they often constitute reservoirs of infection which may give rise to epidemic outbreaks. A purpose of this paper was to characterize endemic foci. While an epidemic situation demands short-term measures of control and prevention, an endemic situation is much more complex and involves long-term measures. In the study area, potentials for both

endemic and epidemic situations exist.

Trends in cholera mortality and incidence in the State of Tamil Nadu during the period 1921-1974 were studied for the State as a whole, and, wherever possible, for the different districts during the period 1961-1974. Mortality and available morbidity data were obtained from the Public Health records for the study of the distribution patterns at the district levels. Prior to 1950, cholera mortality was high, but since 1950 declining trends in mortality was evident. The last epidemic in the State occurred in 1963. Even though mortality rates have declined considerably throughout the region, cases are still being reported in all the districts.

From 1961 to 1974 in Tamil Nadu it appears that cholera incidence and endemicity persisted at relatively moderate levels in the northern coastal districts of Madras, Chingleput, North Arcot, South Arcot and Thanjavur; in the interior districts of Salem, Dharmapuri, Coimbatore, Tiruchirapalli and Madurai, a moderate to low level of persistence was noted. Only sporadic cases were reported in the remaining southern districts of Ramanathapuram, Tirunelveli, and Kanyakumari (except in 1973). Contrary to earlier patterns (1885-1950), for the period of 1961-1974 the northern coastal districts (which included previously Thanjavur and South Arcot) are seen as noticeably low in endemicity. The decline in cholera mortality and incidence indicates to some extent that increasing control over mortality has been achieved.

A study of geographic distribution and intensity of disease incidence helps not only to identify areas of frequent occurrences, but also to assess the nature and amount of preventive, diagnostic and treatment facilities which are needed and where they are needed. No attempt has been made so far by the Statistical Division of the Public Health Department to identify areas of under-registration in different parts of the State or to correct and improve standards of the registration system for reporting cases or causes of deaths. Because it was suspected that registration efficiency in all the districts was not uniform, potential error was reduced by considering the trends in both mortality and case occurrences in order to arrive at generalizations concerning its persistence and endemicity levels.

Compilation of health data related to mortality and morbidity statistics encounters many difficulties, for instance, clinical sources of data are limited. Often cholera cases are not reported because of ignorance concerning actual symptoms; it is confused with indigestion or gastrointestinal upset or with other diarrhoeal and dysentery infections. Diagnostic facilities are often limited in rural areas where participation in community health programs is minimal. Morbidity statistics are found to be less reliable than death statistics; cause of death statistics in municipal areas were found more reliable than in rural areas. Registration systems need improvement in terms of routine data collection of vital statistics especially in rural areas. The systems for storage and retrieval of data from public health records also need to be standardized in order to improve the accessibility of data.

However, recorded data of registered deaths and cases are available from 1961 on for all the districts of Tamil Nadu which were used in this study. Demarcation of endemic tracts of cholera can be based on recorded monthly statistics of cholera (cases and deaths) provided at the district level.

Using data solely from large administrative divisions such as districts limits detailed description of the significant epidemiological and ecological areas. A more meaningful classification of regions such as coastal areas, foot hill tracts, valleys, river basins, or nodal points would provide a better framework for identifying endemic foci. However, quantitative assessments at district administrative levels do allow presentation of information on cholera incidence and spread, of value to regional authorities in their efforts to control and prevent disease. They also provide health measurement for area populations, a means of comparing areas and years.

Planning to eliminate endemic diseases involves an understanding of its epidemiological characteristics in different areas; the characteristics differ from one area to another. Only limited information was available on the epidemiology in the study area. The agent and host characteristics were discussed in general; the environmental conditions favouring infection and its propagation were investigated with special reference to the study area. Cholera is likely to occur only when certain favourable factors, both natural and cultural, exist. Some of these as discussed in the study are summarized in the following paragraphs.

Strains of classic cholera were supplanted by the El Tor biotypes throughout India in the early sixties and now the El Tor types predominate in the State of Tamil Nadu also. Since it first appeared, this mild type of vibrio cholera is found to exhibit a low mortality rate, though cases were reported in large numbers. It is found to be more resistant to various environmental factors and antibiotics, and it also survives longer in the environment. However, according to W.H.O., this difference is not of epidemiological significance. A problem lies in detecting and isolating cholera cases from other mild diarrhoeal illnesses, especially during the early stages. In most cases, sources of infection are hard to trace. Human beings are the only reservoir of infection and environmental agents such as water, flies, etc., play a temporary or secondary role in the process of transmission. Endemicity, in addition to carriers, requires environmental agents, the secondary agents in the act of transmission, such as those commonly found in contaminated water supplies, and as a result of low standards of sewage and waste disposal, practices which allow excreted vibrios, contamination of food such as milk, vegetables, fruits, etc.

Epidemics occur when the number of carriers goes unchecked, as evidenced in other epidemiological studies done in Hong Kong, Philippines and India (W.H.O., 1967b). Although only a few case studies have been conducted on cholera carriers in India, some have been done in the cities of Calcutta (Seal, 1966), and Delhi (Pal, et.al., 1973). In the State of Tamil Nadu, human carrier studies are initiated at the

King Research Institute of Preventive Medicine in Madras City; investigations into the pathological and immunoserological characteristics of the carrier state have yet to be performed. Carrier studies are difficult to perform because of intermittent passage of organism. Carrier studies deserve high priority in the field of communicable diseases; further research is essential for effective cholera control and the elimination of endemic foci.

Areal behaviour patterns of cholera were observed by analyzing distribution at district levels, however, it was not possible to completely explain relationships in strictly geographic terms due to limited information on specific areas in the State and lack of intensive field surveys. The exception was a detailed epidemiological study done by Swaroop (1951) on cholera incidence in the Cauvery deltaic region. Information on environmental relationships in incidence was restricted to available information which was gathered and synthesized from scattered sources such as interviews with public health officials and the few printed documents or articles available on general health conditions in the State, and field enquiries.

Cholera is mainly a water-borne disease in Tamil Nadu; historically it was found in those areas encompassing the intersection of rivers and streams, irrigated areas of paddy cultivation, and in some of the river valleys and deltas of the norther coastal districts. Infection was often found to spread downstream along the rivers, as occurred in the Cauvery River basin. With the development of transportation networks, there is no longer a definite pattern or route which can be easily traced in the spread of cholera. This is now further complicated by increasing urbanization, rural-urban migrations and other population movements, such as seasonal agricultural workers and labor migrations for development projects (both internal and external) in the State. Lack of evidence from carrier studies hampers explanation as to the extent to which such population movements influence cholera incidence.

It appears that the east coast regions of Tamil Nadu, comprising the districts of Chingleput, Madras, North Arcot, South Arcot, and Thanjavur, provide a favourable environment for cholera occurrence. Following are some of the environmental factors with the potential for contributing to cholera occurrence: ample rainfall, extensive networks of canal and tank irrigation, relatively high density of rural population, prosperous agricultural conditions giving rise to greater population mobility, low standards of environmental hygiene and sanitation, and the existence of numerous pilgrim and religious centers that hold seasonal fairs and festivals.

Knowledge of seasonal characteristics of cholera occurrence in Tamil Nadu helps in developing adequate public health measures for anticipated outbreaks. Some correlation was found between the major incidence of cholera occurrence and the favourable conditions existing in the cool, dry, post-monsoon season of December and January. For example, prior to 1971, in almost all the districts of the State, the highest percentage of annual deaths and attacks was reported during the

December-February period. However, observations for the recent period, 1971-74, indicate an even distribution in incidence over all the months. This change in pattern needs some explanation. Factors contributing to this deviation from the expected seasonal characteristics of incidence are a general failure of rains in 1973-74, the resultant water scarcity, food shortages and adverse economic conditions.

In India, a relationship between outbreaks of cholera and pilgrim centers at peak season during festivals and fairs has been recognized. The study area is the home of a large number of important religious and fair centers, located in traditional endemic areas. Public health authorities recognize the potential hazard of carriers in such centers, as evidenced by the intensive anti-cholera innoculation campaigns of 1956-60 which effectively reduced outbreaks in many of these centers. Innoculation measures still continue to play an important role in averting seasonal outbreaks and spread in the State's cholera control program.

An effective surveillance system assists in the early detection and control of communicable diseases and their spread. No one simple solution exists to the problem of cholera. Its eradication depends heavily on the nature and spatial extent of control and surveillance activities which involves both short-term measures dealing with immediate epidemic situations and long-term programs of providing basic health services. The question of eradication of the endemic situation in the State has been given practical consideration only since 1969; before then control activities dealt with epidemic situations as they arose. Even with low intensity of occurrence, the incidence seems to shift its boundary from place to place in a somewhat diffused pattern either through the movement of active cases or possible carriers. Thus, the problem remains in tackling endemicity each time it re-appears.

There are various measures for cholera control, treatment and prevention; measures are available if an epidemic strikes in the State. Communicable disease control programs in rural areas are operated by basic health centers. Even though their numbers have increased since 1961, primitive facilities are offering only low capacity health services; the base population to be covered ranges between 80,000-100,000 per primary health center.

A centrally-sponsored cholera control program and team have existed in the State since 1972, covering the number of administrative blocks in each of four State-selected endemic districts of North Arcot, South Arcot, Tiruchirapalli and Coimbatore. The program is to be extended to the remaining 50 percent of the blocks. Epidemic control units, consisting of seven mobile and three epidemiological units, and one cholera combat team, have also been introduced in the districts of Thanjavur, North Arcot and Tiruchirapalli. These function mainly as innoculation teams and are just beginning to develop surveillance activities and to assist in local epidemics when reported. They also provide facilities for treatment, disinfection, and environmental protection measures, such as safe disposal of excreta and dead bodies, safe water supply and health education during epidemics. The introduction of epidemic units in selected regional territories is a first step towards the development of a surveillance network system which helps to detect early outbreaks and distribution in the community.

Anti-cholera innoculation campaigns continue to be carried on as a preventive measure during the period of expected cholera outbreak. However, the immunity conferred by the vaccine is found to be of short duration lasting only three to nine months. Special measures of vigilence have yet to be developed for protecting vulnerable areas such as coastal zones of contacts, nodal points, travellers, customs officials and other endemic foci.

Importation of cholera infection from outside the State is often suspected. Regular exchange of epidemic intelligence between the States is limited, even though interstate population movements are increasing. There is no Act of the Central government co-ordinating the control of epidemic diseases in India, which makes it difficult to enforce an effective exchange service between the States.

The majority of the population lives in rural areas where, for the most part, protected water supplies are nonexistent; therefore, water-borne diseases are prevalent in many of these endemic villages. The Water Supply and Drainage Board of the State Government in their plans and proposals has already identified many of these villages for providing water and chemical traatment facilities, but total coverage is not yet possible because of financial and technical difficulties. Furthermore, the Task Force Report on Health states that only 50 percent of the urban population are served by a chemically treated water supply to varying degrees of adequacy. Yet rural areas lag severely behind the urban areas.

The enforcement of many of the Public Health Act regulations remains ineffective; practical application has been neglected, lacking either funds or initiatives on the part of local bodies as well as the Public Health Department of the State. This Act (Tamil Nadu, Public Health Act, 1939) and its bylaws, strictly applied, would allow tremendous scope for improving rural and urban sanitation and health in the State. Until then, environmental hygiene and sanitation will continue to function at a low level in the State, and continue to negatively influence disease incidence and its propagation.

The present cholera prevention measures to improve sanitation are found to be ineffective and cannot achieve the desired control as evidenced in this study by the continuous occurrences of cases with low level of intensity in almost all the districts in the State. W.H.O. (1967b, p. 29) Studies on selected cholera endemic areas conclude that the development of simple and practical devices for the disinfection of water, food and wastes under field conditions deserve further investigation, research, and action. The provision of safe water supplies by means of protected wells, tanks, etc., in the rural areas, and improvement of chlorination and purification methods in urban and semi-urban towns have always been discussed and reported in documents. But such measures of prevention and control have been slow and far from satisfactory; a paucity of funds and priority of other emergency health needs have allowed only stop-gap measures in dealing with the eradication of communicable diseases. Even though cholera may appear to have lost its intensity and declined in incidence, the environmental conditions favourable for its recurrence still exist in almost all the areas of Tamil Nadu.

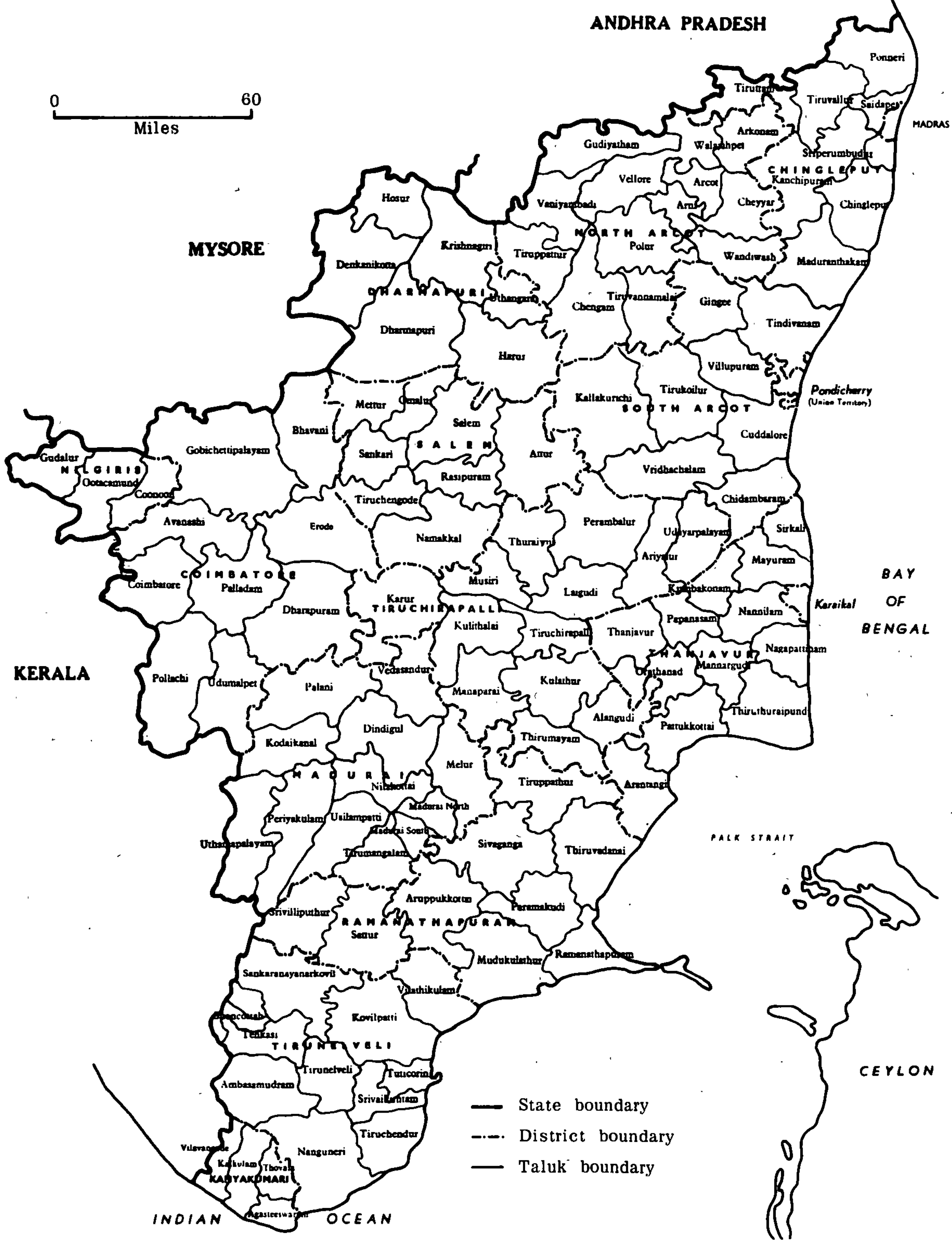
The improvement of environmental sanitation is one means of attempting to control diseases like cholera; another is the improvement of the social and cultural environment in which the people live. Public health education is essential to countering the low level of literacy, personal hygiene and sanitary habits existing in both the rural and the urban areas. Long-term control depends to some extent on the status of community health and education at the present time. A minimum awareness, acceptance and participation in health programs is evident. This, in turn, reflects a broader professional role for public health personnel, who must now not only "sell" programs, but, in the process, invite co-operation and participation from within the community. Public health education techniques need to be developed throughout extended area-wide networks covering the State.

Investing much effort and resources in the control of communicable diseases such as cholera, smallpox, and malaria in the fifties and early sixties brought about a significant decline in their incidence, which, in turn, resulted in a slackening of these same measures of control and eradication. Although medical science has made available relatively efficient and inexpensive techniques for treatment and prevention, economic and social progress have lagged behind, making possible the recrudescence of many diseases which were thought to have been brought under control. The control and prevention measures compete for the limited funds and personnel allocated to total health services; higher priority has traditionally been given to curative medicine, and increasing resources are being assigned to family planning programs, leaving less to combat communicable diseases. Eradication of infectious diseases depends on the continuity of effort in building up an efficient network of surveillance activities as a component of overall basic health services.

This research found that medical geography work and literature in the study area in recent times are almost nil. Hardly any research had been undertaken by geographers or epidemiologists to examine geographic distribution and changing patterns of communicable diseases in the study area. Vast potential exists in terms of future levels of medical geographic research to promote health care systems in development planning. There is a definite need for filling the gap at macro and as well as at micro-level in the geography of the study of diseases.

APPENDIX I

TAMIL NADU DISTRICTS AND TALUKS



APPENDIX II

APPENDIX II

PHYSICAL AND CULTURAL CONDITIONS FAVOURABLE FOR DEVELOPMENT, TRANSMISSION AND SPREAD OF CHOLERA

Location

Incidence rates found significant in:

- areas with low altitude, deltaic and coastal areas within 100 miles of east coast (Asia)
- settlement areas primarily at the intersection of rivers and streams
- villages located on river banks or near the banks of irrigation canals
- areas experiencing floods, drought, famine and earthquakes

Soil

Vibrio cholera thrives in:

- new alluvial soil
- warm, moist clay
- alkaline conditions
- areas with ample organic content in the surface water from the fields and settlement

---

Summarized mainly from:

1. World Health Organization, Principles and Practice of Cholera Control (1970), pp. 23-107.
2. Banerjee and Hazra, Geo-Ecology of Cholera in West Bengal (1974), pp. 19-88.

For full reference, see bibliography at the end.

Climate

Vibrio cholera thrives in:

- Climatic conditions with high temperatures, high absolute humidity, e.g., in urban areas heat accelerates the decomposition of accumulated garbage which creates environmental pollution

- Seasonal conditions such as monsoon seasons with heavy rainfall, and drought conditions with lack of rain

Water Characteristics

Survival time of vibrios and environmental contamination in water depends upon:

- high pH values found in endemic areas

- salt and carbohydrate concentrations

- high water table

- presence of organic matter and other bacterial flora

- seepage water mingled with vibrio cholerae

Vibrio cholerae survives:

- 1-2 days in river water with bacteria

- 1-5 days in contaminated water by river, tanks, and canals

- 7-13 days in clear water

- 17 days at room, sterile filtered autoclaved water
- up to 42 days at 5° and 10° C

Water Supply and Environmental Hygiene

Ways in which water can play an important role in the transmission of vibrio cholerae:

- The lack of an adequate and protected water supply for personal uses encourage the use of contaminated water.

- Open wells, canals, springs, tanks and ponds are open to infection.

- Wells and springs, when used as public water supplies, increase the risk of contamination.

- Reservoirs with fishing and boating activities are sources of pollution.

- Water used in public places spreads disease quickly.

- Infected individuals on the river or canal banks, engaged in bathing, washing, or drinking, pass infection into the water.

- Fringe or slum areas have inadequate utility services, therefore water becomes contaminated quickly.

- Existing open drains and surface drains are often linked with ponds and tanks, therefore risk infection.

- Water distribution systems, especially in urban areas, have poor leak-proofing and risk contamination at joints and cracks.

- An intermittent supply of filtered water can create negative pressures resulting in pollution through old pipes, a place for cholera bacteria to thrive.

- Storing filtered water in concrete reservoirs with inadequate coverings can cause contamination.

- Tube wells for all purposes are prone to infection.

- Underground water reservoirs in multi-storied apartment buildings become susceptible to water pollution because tthey lack adequate drainage facilities.

- Poor drainage creates water logging, especially in urban slums.

<u>Standards of Health: Personal Hygiene and Sanitation Habits</u>

Dissemination of cholera infection is facilitated by:

- human defacation habits
- inadequate sanitary facilities (poor excreta disposal installations)
- bore hole latrines pollution by ground and surface water

- Cholera maintained in a cycle involving vibrios excreta and sources of water, e.g.:

  - drinking water polluted by infected excreta

  - accessibility of wells to surface wash or seepage

  - contaminated ground water (through seepage)

  - fecal matter transported by rain water, human feet, animals, flies or pests

  - contamination occurring in food, surface water, and on kitchen utensils

  - flies transporting vibrios from food

  - night soil (The bucket system for collection and disposal of excreta creates risks for handlers during epidemics, spillage, leakage, careless handling, breeding of flies and vermin, all cause transmission of cholera organisms.)

Food

Cholera transmission is possible as a result of pollution of food; several factors are involved:

- the practice of irrigating vegetables and fruit gardens with sewage-polluted water

- fertilizing the ground with fresh night soil

- the use of fish and shellfish caught in polluted waters for human consumption

- handling of food stuffs by cholera patients

- unsanitary handling of food otherwise

- washing of utensils in contaminated water

- consuming raw or partially cooked food

- laboratory studies show that vibrios multiply readily in certain foods, milk and milk products, and some varieties of boiled rice. (e.g., the addition of salt to fresh fish, meat, watermelons, boiled rice and salads, jellies and cold drinks prepared in unsanitary conditions (roadside food-stalls) provide an excellent propagating media.)

- unhygienic practices in public places (markets, restaurants, and other eating places)
- storing, processing and serving food in restaurants and other eating places
- street vendors handling an abundance of food in open markets
- washing vegetables with unfiltered water before marketing
- selling of unprotected food in the open markets, attracting flies, etc.
- the production of wastes and the presence of flies
- water supply provisions, sewage, unsanitary toilet facilities in market and eating places
- poor facilities for refuse collection and waste disposal; accumulated refuse dumps in towns and cities create environmental pollution

Social and Demographic Aspects

Susceptible population and carriers can be identified in some instances:

- population in high density, deltaic, wet, paddy cultivation regions
- incidence tends to be high among low socio-economic groups
- population in overcrowded living quarters, slums, urban fringe areas with poor sanitary standards and disciplines, low level of educational attainment, restricted intake of food of susceptibles
- sex differences in incidence in areas where only the mobility of adult male population is significant
- age affects adults in epidemic areas, except epidemics in newly invaded areas;
  in highly endemic areas exposure in early life leads to development of a continuously reinforced immunity;
  the attack rate is highest in children, especially age groups 1-4 years

- in endemic areas mild diarrhoea due to vibrio cholerae is more often found in children than in adults

- lapse of some years, since the last cholera epidemic may have increased the available number of susceptibles in a given area.

Population Movements

- congregation of susceptibles and carriers at fairs and festivals in huge numbers, often during March-April, when surface water is at low level leading to contamination

- traffic along sea/river/railroad routes (notal points) coastal towns and fishing villages get affected

- traders and fishermen spread infection

- markets and fairs where population gathers in large numbers

- labor migration (seasonal) into areas with development projects, such as irrigation, mining, industry, road and bridge construction, plantation, and planting and harvesting seasons.

APPENDIX III

APPENDIX III

ENVIRONMENTAL HEALTH MEASURES FOR CHOLERA PREVENTION AND CONTROL

Safe water supply:

Measures applicable to water supply of urban centers:

- constant vigilence over public and private water systems
- inspection of all sources of pollution and potential pollution
- chlorinating during emergencies
- disinfection of distribution system
- provision of water through portable tanks in slums and fringe areas when individual water points get contaminated
- frequent bacteriological examination of the source of water supply at all factories using public water
- water works in large towns should be provided with laboratory facilities
- maintenance and operation of sewerage treatment systems

Measures applicable to water supply of rural communities:

- disinfection of sources of drinking water
- protection of dug wells serving whole villages

Excreta disposal:

- location of latrines should be at lower levels than wells,

Summarized mainly from:

1. J. de Araoz and D. V. Subramanyam (W.H.O., 1970)
2. D. Barua (W.H.O., 1970)
3. Indian Journal of Public Health (October, 1972)
4. J. H. Mathur (1973)

For full reference, see Bibliography.

springs, ponds (if found near these places); location near rivers, tanks and reservoirs should be avoided

- the bottom of latrines is recommended at least 1.5 m. below the ground water table
- additional precautions in location should be taken where rock formations have fissures (e.g., limestone areas)
- trench latrines (with series of seats or squatting holes) should not be used for more than 3-6 week period; they should be covered; heavy spray of strong chlorine solution and disinfection must be a routine feature
- special precautions and measures should be taken for the disposal of excreta in hospitals, restaurants, slums, and fringe areas

Food control:

- training of health inspectors
- control of street food vendors and open markets
- supervision of hygiene in restaurants and eating places
- proper disposal of refuse collection in established markets
- proper facilities for washing and disinfecting fruits and vegetables
- detection and prohibition of irrigating with sewage polluted water, and fertilizing with fresh night soil

Fly control:

- screening and immediate disposal of refuse
- routine inspection of conditions in city refuse dumps
- use of fly proof containers in public market places
- control of unsanitary toilet facilities

Personal Measures:
(where there is an epidemic outburst or suspected threat)

- innoculation of anti-cholera vaccines; immunity develops within 4 days and lasts for 6 months

- empty stomach to be avoided
- abdominal disorders to be checked by a doctor
- use of only warm and cooked food
- avoid food such as over-ripe or under-ripe vegetables and fruits, fish, cold meats, shellfish, salads, bazaar-made sweets and drinks, fresh fruit juices, soda water, lemonade, ice cream, etc.
- use of boiled and cooled drinking water, curd, weak tea, lemon juice, coconut water, etc.

Precautions in the House:

- cook, servers (all food handlers), should wash hands in soap and water, and antiseptic solutions
- screen doors and windows to keep flies and insects out
- protection of food from flies
- cleaning of latrines with phenol lotion
- sterilizing cooking pots by boiling and exposure to dry heat

Cholera cases:

- inform municipalities or medical officers
- provision of vigilence and investigation team for early detection and control
- transportation of affected population masses to safe place for protection
- isolation of cholera patients in hospital wards

Special Measures for Control of General Environmental Sanitation:

- safe and adequate water supply
- satisfactory disposal of garbage and night soil
- burning of soiled linen with excreta and vomitus of the patient

- creation of special sanitary arrangements during large fairs, festivals and exhibitions

- control of flies, insects, vermine and hazards due to animals, cows, dogs, pigs, around refuse dumps and garbage disposal bins

- sanitary disposal of dead bodies in infected areas

- adequate supply of food under epidemic circumstances.

SELECTED BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

CHOLERA

Ackernecht, Erwin H., History and Geography of the Most Important Diseases (New York: Hafner, 1965).

Armstrong, R. W., "Medical Geography: An Emerging Speciality," International Pathology, Vol. 6 (1965), pp. 61-63.

Armstrong, R. W., "Medical Geography and Health Planning in the United States," in N. D. McGlashan, (ed.), Medical Geography: Techniques and Field Studies (London: Methuen, 1972), pp. 119-129.

Bailey, N. T. J., "Some Problems in the Statistical Analysis of Epidemic Data," Journal of the Royal Statistical Society, Vol. 17 (1955), pp. 35-68.

Banerjee, Bireswar and Jayati Hazra, Geo-Ecology of Cholera in West Bengal (Calcutta: Bagachi, 1974).

Banks, Leslie A., "The Study of the Geography of Disease," The Geographical Journal, Vol. 125 (1959), pp. 199-210.

Banta, James E. and L. Schuyler Fonaroff, "Some Considerations in the Study of Geographic Distribution of Disease," Professional Geographer, Vol. 21, No. 1 (January, 1969), pp. 87-92.

Bart, Kenneth J., Moslemuddin Khan, and Wiley H. Mosley, "Isolation of Cholera Vibrio from Night-Soil during Epidemics of Classical and El Tor Cholera in East Pakistan," Bulletin of the World Health Organization, Vol. 43, No. 3 (1970), pp. 421-430.

Barua, D., "Survival of Cholera Vibrios in Food, Water and Fomites," in World Health Organization, (ed.), Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970), pp. 29-32.

Basu, Ramola, "Cholera in Calcutta: A Case Study in Medical Geography," Geographical Review of India, Vol. 31, No. 3 (1969).

Bellew, H. W., The History of Cholera in India from 1862 to 1881 (London, 1884).

Bencie, Z. and S. Renuka, "Cholera Carriers and Circulation of Cholera Vibrios in the Community," International Journal of Epidemiology, Vol. 1 (1972), pp. 13-14.

Benenson, Abram S., Control of Communicable Diseases in Man (11th ed.; New York: The American Public Health Association, 1970).

Breslou, Lester, "Implications of Findings for Health Policy," in W. W. Holland, (ed.), Data Handling in Epidemiology (London: Oxford University Press, 1970), pp. 201-206.

Brockington, C. Fraser, "The History of Public Health," in T. H. Wilson and T. Wilson, (eds.), Control of Disease in the Tropics (2nd ed. rev.; London: H. K. Lewis & Co., Ltd., 1971), pp. 1-7.

"Cholera Cycle in 1967-68 - Center Warns State," Health, (Indian Journal), Vol. 43, No. 5 (May, 1965), p. 118.

Cvyetanovic, C., "Cholera as an International Health Problem," in World Health Organization, (ed.), Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970), pp. 9-14.

Davey, T. and T. Wilson, (eds.), Control of Disease in the Tropics (2nd ed. rev.; London: H. K. Lewis & Co., Ltd., 1971).

de Araoz, J. and D. V. Subramanyam, "Environmental Sanitation in Cholera," in World Health Organization, (ed.), Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970), pp. 95-110.

Dever, Alan G. E., (ed.), "Medical Geography: A Selected Bibliography," International Pathology, Vol. 2 (1970), pp. 13-16.

Dhillon, H. S. and S. P. Kar, "Behavioral Science and Public Health," Indian Journal of Public Health, Vol. 7 (1963), pp. 19-24.

Dutta , M. K., "The Diffusion and Ecology of Cholera," Geographical Review of India, Vol. 35, No. 3 (September, 1973), pp. 243-262.

Dutt, P. R., Rural Health Services in India: Primary Health Centre (New Delhi: Central Health Education Bureau, Director General of Health Services, Ministry of Health, Government of India, 1962).

Ehrlich, David, "Fighting Cholera," Health, Vol. 43, No. 9 (September, 1965), pp. 221-222.

"Epidemiological First Aid and Follow Up in Natural Calamities," Indian Journal of Public Health, Vol. 16, No. 4 (October, 1972), pp. 1-2.

Felsenfeld, O., Review of Recent Trends in Research and Control of Cholera (Geneva: W.H.O., 1965).

Fonaroff, L. S. and A. Fonaroff, "The Cultural Environment of Medical Geography in Rural India," Pacific View Point, Vol. 7, No. 1 (May, 1966), pp. 67-68.

Forewell, G. D. and J. H. F. Brotherston, "Medicare," in T. H. Davey and T. Wilson, (eds.), Control of Disease in the Tropics (2nd ed. rev.; London: H. K. Lewis & Co., Ltd., 1971), pp. 397-452.

Fox, John P. et al., Epidemiology: Man and Disease (New York: Macmillan, 1970).

Fry, John and W. A. J. Fardale, (eds.), International Medical Care: A Comparison and Evaluation of Medical Care Services throughout the World (Washington Square, East, Pennsylvania, 1973).

Gale, G. W., "Some Factors affecting the Rural Health Services in Developing Countries," The Lancet, Vol. 288 (1965), pp. 696-697.

George, A. J., "Public Health of Salem District," The Journal of Madras Geographical Association, Vol. 2, No. 2 (July, 1936), pp. 141-145.

Gill, C. A. and R. B. Lal, "The Epidemiology of Cholera with special reference to Transmission," Indian Journal of Medical Research, Vol. 18 (1930-31), pp. 1255-1297.

Girt, John L., Geography and Non-Vectored Infectious Diseases, paper presented at the First Carolina Geographical Symposium, University of North Carolina, Chapel Hill, March 1, 1974.

Gopal, B., "Compulsory Preventive Innoculation as a Measure of Control of Cholera in Fairs," The Indian Medical Gazette, Public Health Section (November, 1951), pp. 510-511.

Hesterlow, Captain, "The Geographical Distribution of Disease," The Journal of the Madras Geographical Association, Vol. 4, No. 3 (October, 1929), pp. 81-97.

Hobson, W., The Theory and Practice of Public Health (London: Oxford University Press, 1969).

Holland, W. W., (ed.), Data Handling in Epidemiology (London: Oxford University Press, 1970).

Holland W. W., "Principals of Study Design," in W. W. Holland, (ed.), Data Handling in Epidemiology (London: Oxford University Press, 1970), pp. 45-54.

Hopps. H. C., et.al., The Mapping of Disease (MOD) Project, Joint Report of the Universities Associates for Research and Education in Pathology and the Armed Forces (Washington, D.C.: Institute of Pathology, 1968).

Howe, Melwyn G., "Some Recent Developments in Disease Mapping," Royal Society of Health Journal, Vol. 90 (1970), pp. 16-20.

Howe, Melwyn G., "Plotting the Scale of Disease," Geographical Magazine, Vol. 44, No. 5 (February, 1972), pp. 304-307.

Hunter, John M., (ed.), The Geography of Health and Disease, Papers of the First Carolina Geographical Symposium (1974), Studies in Geography No. 6 (Chapel Hill: Department of Geography, University of North Carolina, 1974).

Hutt, M. S. R., "The Geographical Approach in Medical Research," East African Geographical Review, Vol. 5 (1967), pp. 1-8.

India, Census of India, 1961, Vol. IX, Madras: Demography and Vital Statistics (Report), Part I-B(i) (Madras: Government of Madras Press, 1965).

India, Census of India, 1961, Vol. XI, Madras: General Population Tables, Part II-A (Madras: Government of Madras Press, 1969).

India, Census of India, 1961, Vol. IX, Madras: Fairs and Festivals, Part VII-B (Madras: Government of Madras Press, 1969).

India, Census of India, 1971, Series 19, Tamil Nadu: General Population Tables, Part II-A (Madras: Government of Madras Press, 1973).

Indian Council of Medical Research, Government of West Bengal, and World Health Organization (Cholera Study Group, Calcutta, India), "Cholera Carrier Studies in Calcutta," Bulletin of the World Health Organization, Vol. 43, No. 3 (1970), pp. 389-400.

Jolly, G. G., "Cholera and River Waters," Indian Medical Gazeteer, Vol. 61, No. 167 (1926).

Joshi, M. J. and C. D. Deshpande, "Geographical Distribution of Some Diseases Common in Southern Asia," Geographica Medica, Vol. 3 (1972), pp. 5-29.

Khan, R., "Purpose, Scope and Progress of Medical Geography," Indian Geographical Journal, Vol. 46 (1971), pp. 1-9.

Khare, R. S., "A Study of Social Resistance to Sanitation Programmes in Rural India," Eastern Anthropologist, Vol. 17 (1964), pp. 86-94.

Klein, Ira, "Death in India," Journal of Asian Studies (August, 1973).

Kratochoil, O., "The Importance of Medical Geography in Medicine," Geographica Medica: International Journal on Medical Geography, Vol. 2 (1971), pp. 74-108.

Learmonth, A. T. A., "Medical Geography in Indo-Pakistan: A Study of Twenty Years Data for the Former British India," The Indian Geographical Journal, Vol. 33 (January-March, 1958), pp. 1-59.

Learmonth, A. T. A., "Medical Geography in India and Pakistan," Geographical Journal, Vol. 127 (1961), pp. 10-26.

Learmonth, A. T. A., "Medical Geography: A Geographer's Viewpoint," Pathologiaet Microbiologia, Vol. 35 (1970), pp. 7-16.

Lilienfield, A. M., "Epidemiology of Infectious and Non-Infectious Disease: Some Comparisons," American Journal of Epidemiology, Vol. 97 (1973), pp. 135-147.

Longmate, N., King Cholera: The Bibliography of a Disease (London, 1966).

Majmundar, N., "Excreta Disposal in Rural India," Indian Journal of Public Health, Vol. 5 (1961).

Mathur, J. H., "Measures against Cholera," Health, Vol. 51, No. 4 (April, 1973), pp. 75-76.

May, Jacques M., "Medical Geography: Its Methods and Objectives," Geographical Review, Vol. 40 (January, 1950), pp. 9-11.

May, J. M. and Suzanne Walsh, "Part VI - Medical Geography (A Programme of Studies of the American Geographical Society)," Indian Geographical Journal, Vol. 26 (1951).

May, J. M., The Ecology of Human Disease (New York: MD Publications, Inc., 1958), pp. 35-56.

May, J. M., "Medical Geography: A Theory of Medicine," Journal of Biosocial Science, Vol. 6 (1974), pp. 187-192.

McGlashan, N. D., "The Scope of Medical Geography," South African Geographical Journal, Vol. 47 (1965), pp. 362-368.

McGlashan, N. D., "Geographical Evidence on Medical Hypotheses," Tropical and Geographical Medicine, Vol. 19 (1967), pp. 333-343.

McGlashan, N. D., (ed.), Medical Geography: Techniques and Field Studies (London: Methuen, 1972).

"Meeting the Threat of Cholera," W.H.O. Chronicle, Vol. 44, No. 11 (November, 1966), pp. 256-257.

Miller, D. L., "Communicable Disease," in W. W. Holland, (ed.), Data Handling in Epidemiology (London: Oxford University Press, 1970), pp. 15-27.

Misra, S. D., Medical Geography of India (Delhi: National Book Trust, 1970).

Momiyama-Sakamoto, Masako, and Kunie Katyama, "Statistical Analysis of Seasonal Variation in Mortality," Journal of the Meteorological Society of Japan, Vol. 49, No. 6 (December, 1971), pp. 494-508.

Momiyama, M. and Katyama, Kunie, "Deseasonalization of Mortality in the World," International Journal of Biometeorology, Vol. 16, No. 4 (1972), pp. 329-342.

Mosley, W. H., "Epidemiology of Cholera," in W. W. Holland, (ed.), Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970), pp. 23-28.

Mosley, W. H., K. J. Bart and A. Sommer, "An Epidemiological Assessment of Cholera Control Programs in Rural East Pakistan," International Journal of Epidemiology, Vol. 1 (1972), pp. 5-11.

Mukhurjee, S., "How to Popularize Latrines in India," Indian Journal of Public Health, Vol. 5 (1961), pp. 27-29.

Mullins, L. S., "Sources of Information on Medical Geography," Bulletin of the Medical Library Association, Vol. 54, No. 3 (July, 1966), pp. 230-242.

Mullins, L. S., (ed.), "The Mapping of Disease: A Special Issue," Geography and Map Division Bulletin, No. 78 (December, 1969), pp. 2-38.

"New Methods to Control Cholera," Health, Vol. 50, No. 7 (July, 1972), p. 166.

"Oral Fluid Therapy brings Cholera Treatment to Rural Clinics," Health, Vol. 51, No. 5 (May, 1973), p. 116.

Pal, S. C., B. S. Misra, D. D. Arora, K. V. Arora, S. Patnaik, C. G. Pandit and J. B. Shrivastav, "Studies on Cholera Carriers in Delhi," Indian Journal of Medical Research, Vol. 61, No. 4 (April, 1973).

Park, C. L., "The Relation between Geographical Distribution and Climatic Factors, and Spread of Plague, Cholera and Smallpox," in Proceedings of Sixth Pacific Science Congress, Berkley (Los Angeles: University of California Press, 1942), Vol. 5, p. 506.

Patnaik, K. C. and P. N. Kapoor, "Why Recurrence of Cholera Epidemic in India?," Indian Journal of Public Health (October, 1965), pp. 157-160.

Patnaik, K. C. and P. N. Kapoor, Statistical Review of Cholera Problem in India (New Delhi: Directorate General of Health Services, Ministry of Health and Family Planning, 1967).

Pemberton, John, "Medical Care," in W. W. Holland, (ed.), Data Handling in Medical Geography (London: Oxford University Press, 1970), pp. 33-44.

Pillai, P. T. N., "Public Health and Its Relation to Environment," Indian Geographical Journal, Vol. 16, No. 4 (October-December, 1941).

Pollitzer, R., "Cholera Studies I, History of the Disease," Bulletin, World Health Organization, Vol. 10 (1954), pp. 421-461.

Pollitzer, R. and Satya Swaroop, "Cholera Studies II, World Incidence," Bull., W.H.O., Vol. 12 (1954), pp. 311-358.

Pollitzer, R., Monograph Series on Cholera (Geneva: W.H.O., 1959).

Pyle, Gerald F., "The Diffusion of Cholera in the United States in the Nineteenth Century," Geographical Analysis, Vol. 1 (1969), pp. 59-75.

Ragavachari, T. N. S., "Forecast of a severe and extensive Cholera Epidemic in India and Precautions against it," Health, Vol. 44, No. 8 (August, 1966).

Raška, K., "Surveillance and Control of Cholera," in World Health Organization, (ed.), Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970), pp. 111-120.

Robinson, D. A., A. J. Radford and N. R. E. Fendall, "Fallacies in Comparing International Disease Trends," Journal of Biosocial Science, Vol. 6 (1974), pp. 279-292.

Rogers, L., "The Incidence and Spread of Cholera in India, Forecasting and Control of Epidemics," Indian Medical Research Memoirs, Vol. 9 (March, 1928).

Rogers, L., "Cholera Incidence in India in relation to Rainfall, Absolute Humidity and Pilgrimages: Inoculation of Pilgrims as a Preventive Measure," Transactions of the Royal Society of Tropical Medicine and Hygiene, Vol. 38 (1944).

Rogers, L., "Progress and Control of Cholera in India by Inoculation of Pilgrims," British Medical Journal, Vol. 2 (December, 1952), pp. 1219-1220.

Russell, A. J. H., A Geographical Survey of Cholera in the Madras Presidency from 1818 to 1927 (Madras: Government Press, 1928).

Russell, A. J. H. and E. R. Sundararajan, "The Epidemiology of Cholera in India," Indian Medical Research Memoir, No. 12 (1928).

Saha, A. L., A. K. Chakraborty and K. Choudhury, "Measurement of Variation in Epidemic Prevalence of Cholera in India," Indian Journal of Medical Association, Vol. 54, No. 1 (1970), pp. 12-20.

Seal, S. C., "The Problem of Cholera in India," The Indian Journal of Public Health, Vol. 4, No. 1 (January, 1960), Supplement.

Shannon, Gary W. and G. E. Alan Dever, Health Care Delivery: Spatial Perspectives (New York: McGraw Hill, 1973).

Shattuck, G. C., Diseases of the Tropics (New York: Appleton Century Crofts, 1951), pp. 314-318.

Simmons, J. S., et.al., Global Epidemiology: A Geography of Disease and Sanitation (London: Lippincott & Co., 1954).

Shoshin, A. A., Fundamentals of Medical Geography, Department of Army Translation, No. J. 5264, Washington, 1968.

Sinha, R., B. C. Deb, B. K. Sirkar, Gareeb A. H. Abou and D. L. Shrivastava, "Role of Carriers in the Epidemiology of Cholera in Calcutta," Indian Journal of Medical Research, Vol. 56, No. 7 (1968), pp. 964-978.

Smith, Alwyn, "Morbidity Statistics, A Report on Current Practices in Member States of WHO," Bulletin, W.H.O., Vol. 40 (1969), pp. 569-591.

Sopper, H. C., "The Interpretation of Periodicity in Disease Prevalence," Journal of the Royal Statistical Society, Vol. 92 (1929), pp. 34-61.

Stamp, L. Dudley, Some Aspects of Medical Geography (London: Oxford University Press, 1964).

State Planning Commission, Tamil Nadu, Rural Water Supply, Unpublished Report of the Task Force on Rural Development (Madras: State Planning Commission, April, 1972).

State Planning Commission, Tamil Nadu, Towards a Healthy Society, A Report prepared by the Task Force on Health, Family Planning, Nutrition and Sanitation, 1972-1984, Plan Document No. 3 (Madras: State Planning Commission, August, 1972).

Stoddart, D. R., "Geography and the Ecological Approach: The Ecosystem as a Geographical Principle and Method," Geography, Vol. 50 (1965).

Strassburger, Emily, "Problems of Health Care in a South Indian State," International Development Review, Vol. 15, No. 4 (1973), pp. 22-26.

Swaroop, Satya and M. V. Raman, "Endemicity of Cholera in relation to Fairs and Festivals in India," Indian Journal of Medical Research, Vol. 39 (1951), pp. 42-49.

Swaroop, S., "Endemicity of Cholera in India," Indian Journal of Medical Research, Vol. 39, No. 2 (April, 1951), pp. 141-157.

Swaroop, Satya, "Epidemiology of Cholera in Madras Presidency," Indian Journal of Medical Research, Vol. 39, No. 2 (April, 1951), pp. 185-196.

Tamil Nadu, Government, Law Department, The Tamil Nadu Public Health Act, 1939, Tamil Nadu Act III of 1939, Act as modified up to the 8th January, 1970 (Madras: Government of Tamil Nadu Press, 1970).

Taylor, Ian, "Administrative Aspects of Communicable Disease Control," in T. H. Davey and T. Wilson, (eds.), Control of Disease in the Tropics (2nd ed. rev.; London: H. K. Lewis and Co., 1971), pp. 270-273.

Tokuji, Chiba, "Geographical Approach to an Endemic Disease," Geographical Review of Japan, Vol. 40, No. 12 (December, 1967), pp. 679-692.

Uemura, K., "Collection of Data from Established Sources," in W. W. Holland, (ed.), Data Handling in Epidemiology (London: Oxford University Press, 1970), pp. 55-68.

Vasudeva, Rao, "Cholera Levies a Heavy Toll," Health, Vol. 42, No. 1 (January, 1964).

Wessen, A. F., "The Role of Migrant Studies in Epidemiological Research," Israel Journal of Medical Sciences, Vol. 7 (1971), pp. 1584-1591.

World Health Organization, Third Report on the World Health Situation, 1961-64, No. 155 (Geneva: W.H.O., 1967).

World Health Organization, "W.H.O. Expert Committee on Cholera," W.H.O. Technical Report Series, No. 352 (1967).

World Health Organization, Principles and Practice of Cholera Control, Public Health Papers No. 40 (Geneva: W.H.O., 1970).

World Health Organization, "Dread Diseases are Soaring in the Region of India," The New York Times, Tuesday, September 18, 1973.