GEOGRAPHICAL PATTERNS OF CHOLERA OUTBREAKS IN NORTHERN AND LUAPULA PROVINCES OF ZAMBIA DURING THE PERIOD 1978 - 1982

By

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DECLARATION

This dissertation represents my own field and research work and it has not previously been submitted for degree purposes at this or another University.

Signed.......................................

This dissertation of Kenneth Allan Mwalwali Kapansa is approved as fulfilling part of the requirements for the award of the Master of Science in Geography by the University of Zambia.

Signatures of Examiners	Date
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DEDICATION

I dedicate this dissertation to my late grandmother Mirriam, who initiated me into the mysteries of Western Education;

My late father Aaron Mwalwali, a great man in his own small way;

My mother Mary Kang'ombe and my brothers Robinson and Benson, who together painstakingly provided the means;

My wife Moira and children: Kasenga, Chilembo and Pwasha who consciously and unconsciously provided encouragement and inspiration.

ABSTRACT

The central theme in Medical Geography is the study of the spatial variation of disease and general effects of the environment on the occurrence of disease. A disease such as cholera is a disturbance of the normal harmony existing between bodily functions and their environment. Such a disequilibrium must be promptly controlled and contained in order to promote health.

Since a disease such as the cholera infection is a dynamic process which develops through time and space, an understanding of the physical and socio-cultural environmental conditions is vital in the control and eradication of the disease.

Consequently this dissertation seeks to identify, analyse, and explain the spatial relationships, obtaining between cholera occurrences on the one hand and specific physical and socio-cultural factors in Northern and Luapula Provinces, on the other.

The dissertation consists of six chapters. Chapter one discusses briefly the general introduction and lays emphasis on the rationale, objectives and methodology adopted in the present study. Chapter two examines the physical socio-cultural and economic aspects of the study area and how these factors individually or in combinations have influenced the occurrence and spread of cholera in the two provinces.

The third chapter discusses the epidemiology of cholera with special reference to the geography of cholera in Africa in general and in Zambia in particular.

Chapters four and five are the foci of the study. These two chapters offer spatial and temporal analyses of cholera outbreaks and diffusion - focusing especially on the effects of unchecked human migrations across international borders such as those between Zambia and Zaire and/or Tanzania, poor sanitation, riverine and/or lake environment, and natural channels and barriers on the occurrence and diffusion of cholera. To this end statistical tests namely Spearman's rank correlation, Student's t, phi - coefficient and simple correlation tests have been utilised in order to obtain the associations between cholera occurrence and environmental factors.

The study concludes by underlying the basic health problems of the interrelationships of poor sanitation, overcrowding, inadequate sewage and refuse disposal methods, unprotected and contaminated domestic water supply all of which are conditions obtaining in the study area. Consequently solutions and suggestions for the control of cholera in the study area have been advanced.

ACKNOWLEDGEMENTS

The programme upon which this dissertation has resulted began on a very shaky and doubtful note. The beginning was characterised by long uncertain periods of financial destitution as I hopelessly embarked upon the almost impossible task of self-sponsorship in a country where education is supposed to be free.

This was followed (during field research) by two long months of gathering data travelling (often on foot) from one cholera - affected village to another - inevitably contracting a bit of malaria here and suspected cholera there.

In completing this study therefore, I am indebted to a number of institutions, respondents (mostly villages of Northern and Luapula Provinces), friends and relatives for their support and encouragement.

I am grateful to the Ministry of General Education and Culture for granting me paid study leave and to the Directorate of Manpower Development and Training (D.M.D.T.) for sponsoring six months of my Masters' Degree programme and for providing me with a research grant.

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I would also like to thank the Inspectorate and Statistical Offices of the Ministry of Health at the National and Northern and Luapula Provincial Headquarters, the various medical doctors and inspectors of Health, Health Assistants and Nurses at Mansa, Mbereshi, Nchelenge, Kashikishi, Mununga, Kasama, Mbala and Mpulungu. My profound thanks go to all those kind and trusting people too many to mention who, without complaints, provided me with boarding and lodging along the Luapula Valley and in Mpulungu. To my younger brother Godwyn Bwanga and his teacher colleagues such as Siwale and others at Nchelenge, Kashikishi, Mwatishi and Kabuta primary schools go my love and thanks for helping with the legwork during the collection of data.

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CHAPTER ONE

1.00 INTRODUCTORY

1.01 INTRODUCTION

It is a widely known fact that disease is as old as man himself. Through interactions with his environment mankind has been afflicted by a vista of diseases in various locations and time periods-with varying incidence and intensity. In addition, there are myriads of dreadful effects as well. Some of the diseases such as cholera and malaria, for instance, if they do not kill, generally reduce man temporarily almost to incompetence. Furthermore, even though a certain immunity may be developed by man, the apparently healthy people basically have a lowered stamina and efficiency. Briefly, then, disease poses problems to man in terms of morbidity, mortality and long-term debilitation.

Discernibly, disease is a dynamic process which develops through time and over space. Therefore, since it has a real variation, disease has a geography. Thus an understanding of the geographical distribution of a disease such as cholera is an essential factor in the diagnosis of the disease.

Cholera is an acute intestinal infectious disease, characterised by severe and copious diarrhoea and/or vomiting. It spreads through a man-environment transmission cycle and is thus associated with poor sanitation. The disease is best favoured by such environmental factors as high temperatures; moisture; water containing organic matter and salts; areas sheltered from the direct rays of the sun, congregations of susceptibles; and, in some areas droughts while in others floods.

Cholera has the shortest incubation period of any infectious disease and if not treated within the first 3-7 days of its infection it may result up to 60 percent mortality (Jusatz, 1977: 131-2) or even higher. It is such a dreadful and feared disease that it must be promptly controlled.

The disease is endemic in South East Asia whence, since the nineteenth century, it has at irregular intervals sent out great outward waves of its infection. At least seven such pandemic waves have been recorded since 1817 (Stock, 1976: 15). Zambia, like more than seventy other countries in Asia, Africa and Europe, has been affected by the world's seventh cholera pandemic, originating from Sulawesi (Celebes).

Accordingly, the main objective of this study is to attempt to identify, analyse and explain the spatial relationships between the occurences of cholera and certain geographical factors in Zambia. But since only a few Provinces reported cholera outbreaks, the present investigation is confined to the two provinces with highest reporting cholera cases. These are Northern and Luapula Provinces with over 2047 cholera cases and more than 200 deaths due to cholera during the period from October 1978 to December 1982 (Fig. 1.1 and Table 1.1). Thus this study, it is hoped will constitute one of the few empirical works in the Medical Geography of Zambia.

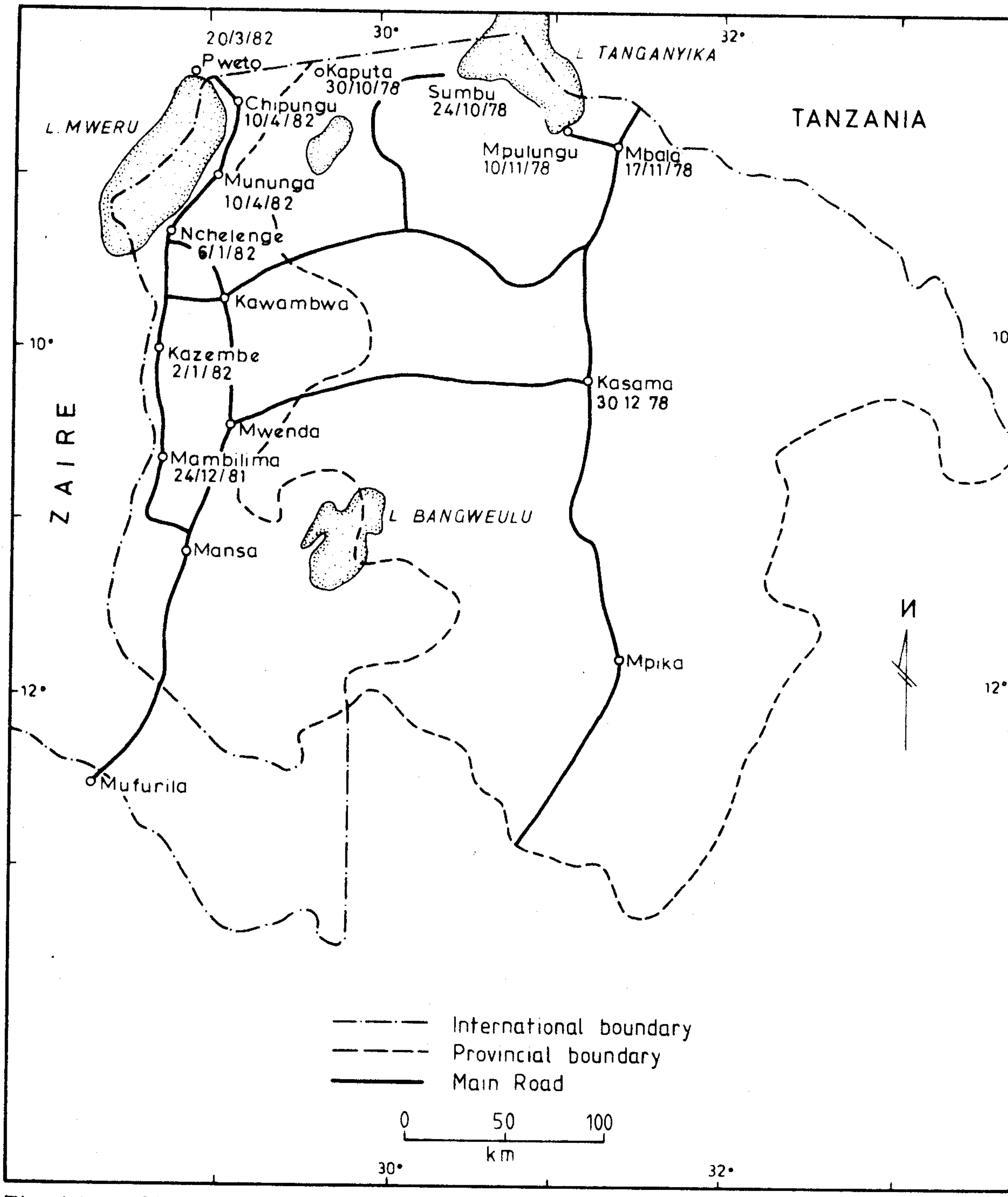

Fig. 1.1 Cholera Outbreaks (by sites & dates) in Northern and Luapula Provinces during the period from 1978 – 1982.

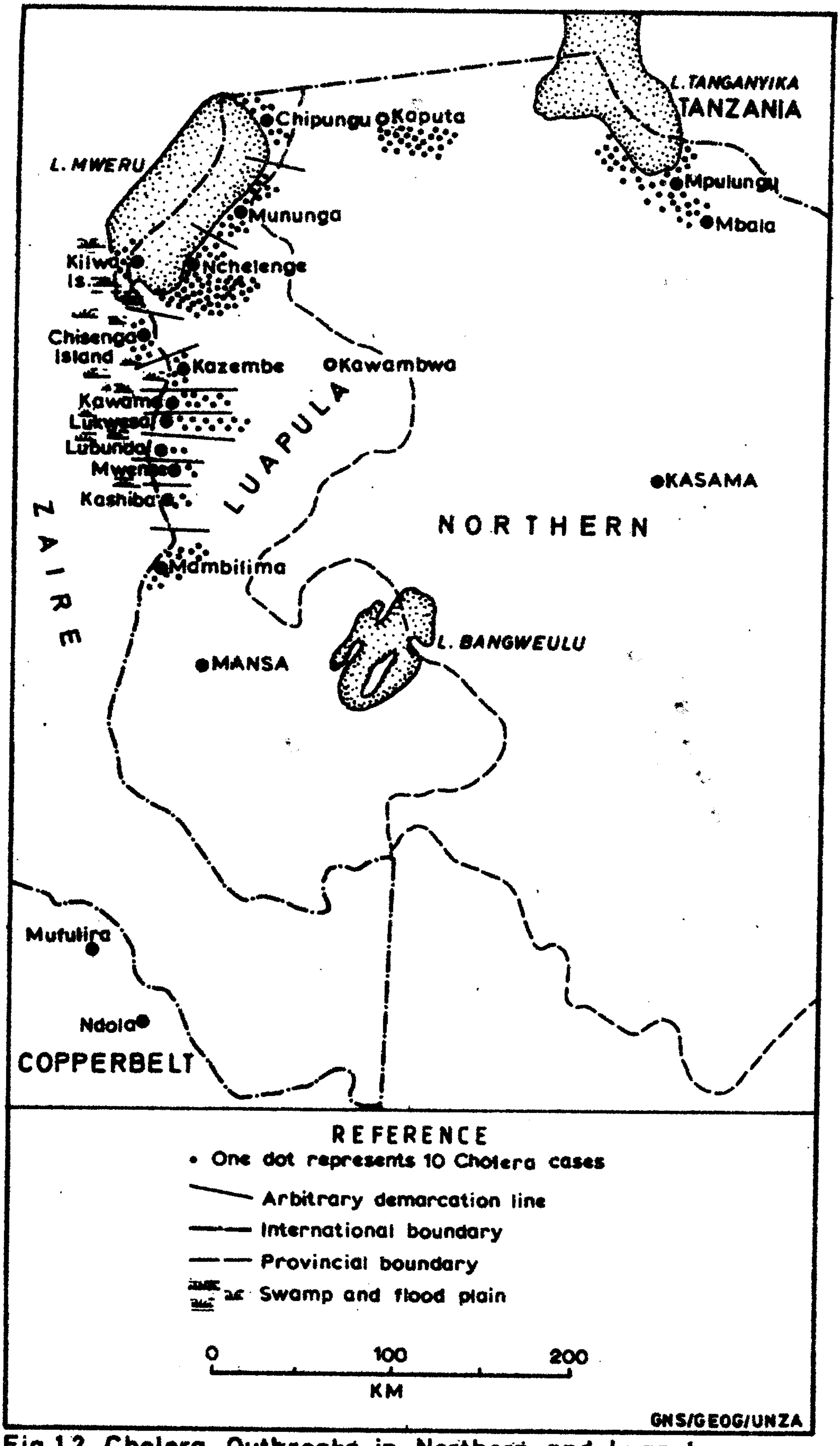

Fig. 1.2 Cholera Outbreaks in Northern and Luapula Provinces, From October 1978 to December 1982.

PROVINCE	NUMBER OF CHOLERA CASES	NUMBER OF DEATHS DUE TO CHOLERA
Luapula	1417	129
Northern	630	72
Copperbelt	15	-
Lusaka	4	1
TOTAL:	2066	202

Table 1.1: Cholera outbreaks in Zambia (October 1978 - December 1982)

Source: Compiled by the author from fieldwork investigation and data collected from the Ministry of Health of the Government of the Republic of Zambia.

Further ,in this introductory part of the study, it is worthwhile to discuss, briefly, the subject of Medical Geography.

Medical Geography, variously known as Nosogeography, Geography of Disease or (more recently) Geography of Health (Akhtar, 1982:2) is a relatively new field of study in geography. It has, in fact, been widely recognized as a field of study only after World War II (McGlashan, 1972:1). Medical Geography is a peripheral subfield between medicine and geography. As such Medical Geography has had the inevitable difficulty of definition and the risk of spilling (during analyses) into either of its component specialities. The result sometimes is that dissatisfaction has arisen on the grounds that geographical analyses and/or explanations of pathological causation have been found inadequate in the eyes of medical men.

This is understandable because the essence of this subfield of study is to utilize geographical skills and methods in order to broaden and deepen the perception of spatial patterns of diseases. Evidently then, the role of geography in medicine is not to usurp the rightful functions of medical practitioners, but rather to be used by them. Geography in medicine can be applied in the identification of possible pathological factors within specified ecosystems resulting from various combinations of geographical factors. The study of Medical Geography is thus basically concerned with the relationship between pathological phenomena (i.e. diseases)and their respective geographical environments.

Although the idea of geographical variation of health problems was first appreciated as early as the fourth century B.C. by Greek scholars and even before them by Chinese and Indian writers (Akhtar, 1982:2), the development of Medical Geography (as a subject), over the centuries, has been extremely gradual and sporadic. This has largely been due to lack of interest in the subject by scholars. McGlashan (1972:6), however, contends that the slow development of the subject has been due to the correspondingly slow progress in technology until after World War II. The years following World War II experienced such a technological boom that the study of medical geography became possible with the application of quantitative methods and computers - particularly in the 1970s.

Jacques M. May, a physician by profession, (1950, 1953) marked the real beginning of Medical Geography through his systematic development of the subject. Extensive studies in human health problems in the West and in the U.S.S.R. then followed.

While those in the West have been, with few exceptions, basically individualistic and mostly academic in nature, the medico-geographical studies in the Soviet Union have been of an applied nature and mostly sponsored by the government. Furthermore, in the Soviet Union, great emphasis has been placed on public health. Discernibly this contributes towards productivity and hence national economic development on socialist lines. In this connection, the Soviets even produce public health forecasts of areas ear-marked for future settlement and development activities (McGlashan 1968). Such studies and forecasts undoubtedly could prove extremely useful in developing countries such as Zambia.

1.02 MEDICAL GEOGRAPHY IN AFRICA

In the greater part of Africa (like in most tropical areas), man and environment are closely linked in complex relationships which usually present conditions of disequilibrium in which diseases thrive while health is impaired (Prothero, 1981: 298-299). Such conditions are found in both rural areas where the majority of the populations are inescapably at the risk of disease, and in urban area into which the rural people (seeking employment and better social facilities) are being attracted. Moreover, the range of diseases to be found - resulting not only from the "favourable" physical environment, but also from socio-economic and cultural environment is particularly wide in Africa (Prothero, 1981:299). It is such "favourable" aspects of the environment which have been significantly instrumental in the occurrence and diffusion of cholera in Zambia as discussed in subsequent chapters.

Besides, as Prothero (1981:299) argues, there is ample evidence in Africa to reveal that those diseases (such as cancers, degenerative diseases of the circulatory system, tuberculosis and psychiatric disorders) formerly prevalent in Western societies are on the increase in this part of the world. An estimated 29.24 per cent of the people in twenty-four African countries suffer from malnutrition and/or under-nutrition (Africa Economic Report, Times of Zambia, February 22, 1984:4).

Such chronic and often acute conditions of malnutrition or undernutrition result from a number of environmental and socio-economic factors. Among the best examples are glaring poverty, severe droughts, and ignorance - all compounded by an unbalanced diet (World Health Organization Chronicles, 1981). Additionally, chronic abuse of alcohol, in some countries of Africa seems to be playing an increasingly significant role in dietary deficiencies.

Notwithstanding the fact that Africa provides such an infinite variety of geomedical problems, relatively few geomedical studies have been carried out in Africa. This is largely because of lack of interest in such researches in the continent-especially by indigenous scholars. Notable examples relevant to the present study include the pioneering works of John Hunter and R.M. Prothero. Hunter (Hunter, 1966) discussed the cyclical retreat and advance of settlement in North-East Ghana consequent upon the impact of river blindness and other diseases, while Prothero (1961, 1963, 1965, 1968) highlighted the significance of human mobility as an important factor in disease transmission.

Others include the studies of R.F. Stock, K.M. Kwofie, H.O. Adesina, and N.D. McGlashan. Stock (1976) produced a comprehensive report which examined patterns of regularity in the occurrence and diffusion of cholera in Africa - with particular emphasis on West Africa. Kwofie (1976) and Adesina (1981, 1982) both studied spatial and temporal diffusion of cholera in West Africa, while McGlashan (1966, 1967, 1968, 1972) contributed greatly to the development of medico-geographical studies in Central Africa.

1.03 MEDICO - GEOGRAPHICAL RESEARCHES IN ZAMBIA

Very few and scattered medico-geographical researches have been conducted in Zambia. These have mainly been done by three scholars. A pioneering researcher who worked in Zambia was Niel D McGlashan. His initial work was a thesis on "Disease distribution in Central Africa" (McGlashan, 1968, Ph.D. thesis). Later he carried out a study on "Blindness in Luapula Province of Zambia." With a brief discussion on the physical background of the area, McGlashan traced the history of blindness in the province and then mapped occurrences of the disease by Enumeration Areas per 1000 of the population, In his final analysis emerged a reasonable pattern of spatial variation of blindness in the province (McGlashan, 1972).

McGlashan, nonetheless, encountered the usual problems of limitation. That is, under-reporting of disease incidence during fieldwork largely because of inaccessibility of some of the areas - particularly swampy areas and islands such as those of Bangweulu, Mweru and Mweru Wantipa lakes.

Besides these studies, McGlashan (1967b) produced a small atlas on the "Distribution of Certain Disease in Zambia." The diseases mapped included smallpox, kwashiokor, tuberculosis of the spine, diabetes mellitus, carcinoma of the cervix and corpus uteri, and carcinoma of the oesophagus.

Mary E. Jackman is another contributor who conducted a research on the "Flying Doctor Service in Zambia" (Jackman, 1972:97). Essentially, her study attempted to describe and categorize medical services according to their sponsorship (i.e. Government, Missionary or Charitable Organisations) and how these were administered. In addition, she discussed the rationale for locating Flying Doctor Clinics where they are - within 56 Km (35 miles) average walking distance of every person in Zambia. She concluded by suggesting that rural health centres (or clinics) could ultimately become natural foci for other social services such as schools, markets or administrative offices.

Lastly, Bryan H. Massam (1974) attempted an analysis of the "Spatial Patterns of Health Facilities in Zambia." Massam applied pattern analysis to classify spatial configuration of health care facilities in the country. He concluded by highlighting the basic importance of the idea of maximizing social welfare while minimizing the average distance travelled.

1.04 RATIONALE FOR THE PRESENT STUDY

Obviously these few works on the Medical Geography of Zambia carried out in the 1960s and 1970s would be even more wanting without a study on the recent outbreaks of cholera in Northern and Luapula Provinces during the period from October 1978 to December, 1982. It is imperative therefore that more studies such as this one be undertaken in order to shed more and fresh light on the spatial patterns of chplera in Zambia.

Cholera broke out in several provinces of Zambia. The highest occurrence was reported in Luapula Province with 69.7

per cent of the total reported cholera cases. The Northern Province comes second with 29.4 per cent; Copperbelt with 0.7 per cent and Lusaka (including Kafue) with only 0.2 per cent. The cholera cases in the Copperbelt and Lusaka Provinces which are almost negligible were clearly transitory (that is, imported from either Northern or Luapula Provinces).

Thus against this background, it is necessary that this present study be carried out in order to highlight such social and geographical factors that were responsible for the outbreaks of cholera in Northern and Luapula Provinces. This would provide greater and deeper understanding of the disease and its patterns, through geographical studies.

1.05 OBJECTIVES OF THE PRESENT STUDY

The present study focusses mainly on the spatial occurrences of cholera outbreaks in Northern and Luapula Provinces of Zambia during the period from October, 1978 to December, 1982. Consequently an attempt has been made to achieve the following objectives:

(i) To map spatial and temporal patterns of cholera diffusion in the two provinces from October 1978 to December 1982.

(ii) To use correlation analysis to identify variables related to the observed diffusion pattern in the endemic areas of Luapula and Northern Provinces.

(iii) To determine ways in which this study of cholera outbreaks in the two provinces can confirm, extend or refute spatial diffusion concepts and models (such as riverine diffusion model as advanced by R.F. Stock (1976)).

(iv) To construct a systems riverine diffusion model showing key relationships involved in the survival and diffusion of cholera in Luapula Province, and a lakeshore model for Northern Province.

(v) To provide a source of information regarding such outbreaks of infectious diseases for future health planning in Zambia.

In addition to these objectives, three main hypotheses have been tested in Chapter four. These are as follows:-

(i) There is a significant relationship between the presence of a river or lake and high incidence of cholera.

(ii) There is a significant relationship between high population density and rapid radial diffusion.

(iii) There is a significant relationship between market towns, transportation nodes (in other words urban importance - that is, government functions:- hospitals, Local courts, secondary schools, government offices, market places) and high cholera incidence.

1.06 METHODOLOGY EMPLOYED IN THE PRESENT STUDY

In the present study the following methods of study have been employed:-

The first one involves mapping cholera occurrences by sites and dates and then by plotting all the 2047 cases (from October 1978 to December 1982) by using dot method (see figures 1.1 and 1.2). Next comes the plotting of cholera diffusion patterns (see chapter five). In order to determine the variable which is more strongly associated with the diffusion of cholera, such interval and/or nominal scaled data were statistically analysed (chapter four).

1.061 DATA BASE

The following two sources have been extensively used for the collection of data and other information:-

(a) Library Source - This included doing preliminary research work and data collection from the Medical Library, National Archives, University of Zambia Library, and the Statistical Division of the Ministry of Health Headquarters.

(b) Fieldwork - This involved:-

(i) Personal collecting of data from Mansa Kawambwa, Mwense and Nchelenge Districts (Luapula Province); Kasama, Mbala and Kaputa Districts (Northern Province).

(ii) <u>Interviews</u> (See Questionaries: Appendices I and II) were conducted at two levels:-

(a) Medical Officers and (b) Surviving cholera victims and non-victims. A sample of twenty medical personnel was randomly selected from the highly cholera affected areas - namely, Mwense (3), Nchelenge (6), Kawambwa (3), Mbala (5), Kaputa (3). These interviews revealed the sites and dates of incidence of cholera. Besides, the possible causes of the disease were elucidated through these interviews.

(b) At the victims level a total of 150 respondents (i.e. surviving cholera victims) and another 150 non-victims were interviewed - To ensure fair representation, a stratified random sampling method was adopted (Table 1.2).

Generally these latter interviews yielded such socio-economic variables as income, house types, size of family, type of diet and sources and types of drinking water used by surviving victims and non-victims. These aspects are discussed at length in chapter four.

CHOLERA AFFECTED AREAS	NUMBER OF CHOLERA CASES	SAMPLE SIZE	
		CHOLERA VICTIMS	NON-VICTIMS
Lukwesa	112	8	8
Kawama	88	7	7
Mwense	23	2	2
Mambilima	142	10	10
Kilwa/Chisenga	139	10	10
Kazembe	45	3	3
Kashiba	35	3	3
Lubunda	22	2	2
Chipungu	88	6	6
Mununga	169	12	12
Nchelenge	556	41	41
Kaputa	271	20	20
Mbala	357	26	26
TOTAL:	2047	150	150

Table 1.2: Sample sizes drawn from cholera affected areas

1.062 LIMITATIONS

In the course of interviews and data collection four main limitations surfaced. These were:-

(a) Lack of information on symptomless (asymptomatic) carriers

It is a well established fact that some cholera patients do not show clinical symptoms but may well be best carriers of cholera vibrios (See chapter three). In fact cholera typically shows up to 100 asymptomatic carriers for every patient with clinical symptoms (Mosley, 1970:26). Thus unless the general population is subjected to intensive bacteriological (or clinical) examinations, these asymptomatic carriers remain undetected (Stock, 1976:5). Consequently there could have been under-reporting in Zambia, Thus the actual reported figures of about 2066 cholera cases and more than 200 deaths could have been much higher.

(b) The size of reporting units

The size of the reporting units was another limiting factor. Cholera cases were just reported from, for instance "Kaputa" or "Nchelenge" without giving the actual locality where the disease broke out. This gives a rather imprecise idea of the actual location and extent of the outbreak. Coupled with this, is the problem of areal demarcation of the units in the study area. In Zambia the lowest (or smallest) areal unit could depend on a number of classifications. For instance, a district could be subdivided into the smallest units on the basis of chief's areas and then villages. It can also be subdivided into constituencies, wards, branches and sections; or district into polling stations or even districts into Enumeration units. The general result during analyses of data based on areal units is rather misleading. Thus areas of units have to be computed as has been done in the present study.

(c) Failure to report the presence of cholera

Some areas did not report the presence of cholera perhaps for reasons of prestige. Cholera is associated with poor sanitation and consequently in some areas where it broke out, people felt ashamed to report its occurrence. In some cases non-reporting resulted from the fear that authorities might interfere with traditional burial rites of particular affected communities.

(d) Inaccessibility of certain cholera affected Areas

Some swampy areas such as those around lakes Mweru and Mweru Wantipa and the islands on these lakes were difficult to reach.

CHAPTER TWO

2.00 THE STUDY AREA

2.01 INTRODUCTION

The study area (Northern and Luapula Provinces) lies roughly between 8^{o} and 13^{o} South of the equator and stretches approximately between $28\frac{1}{2}^{o}$ and 33^{o}E (Fig. 2.1). The Northern and Luapula Provinces together cover about 198370 Sq. Km. (G.R.Z. Census of Population and Housing, 1969). This constitutes roughly 26.36 per cent of Zambia's total land surface. In terms of population the two Provinces comprise about 19.20 per cent of the country's total population (G.R.Z. Census, 1980).

2.02 PHYSIOGRAPHY

The two provinces form part of Zambia's high veld region - a southward extension of the Great African Plateau. Like other plateau surfaces in Zambia, this plateau has resulted from the process of gradation, acting over long geological periods on a relatively stable land mass. Besides gradation, the cycles of erosion have progressed to late Tertiary period resulting in near-peneplanation of rocks with varying degrees of resistance (Davies, 1976:14).

Generally the study area may be divided into the following physiographic regions (Fig. 2.2):-

(i) Land between 600m and 900m (e.g. the narrow strip of land around the southern tip of Lake Tanganyika.);

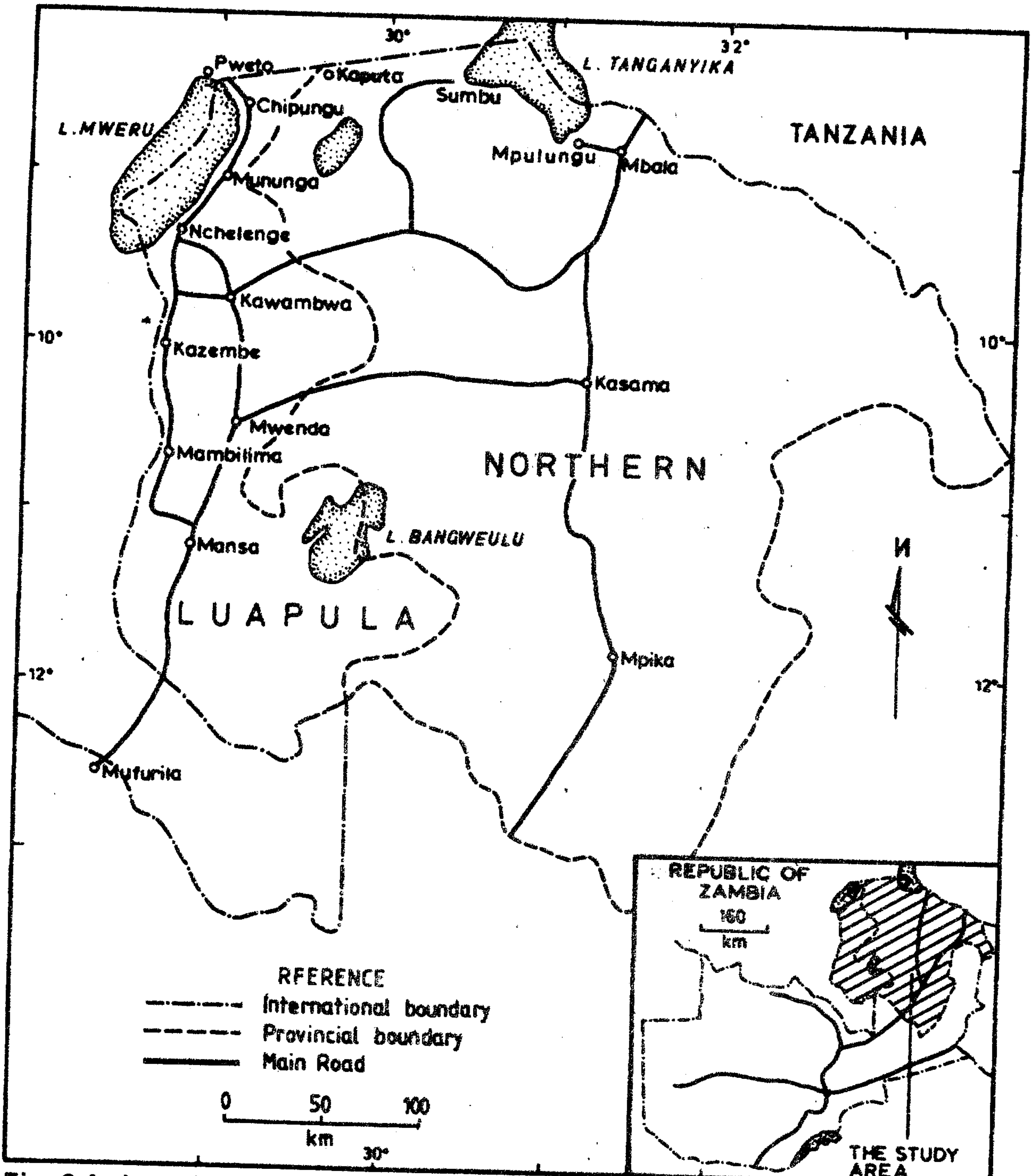

Fig. 2.1 Location and Extent of The Study Area

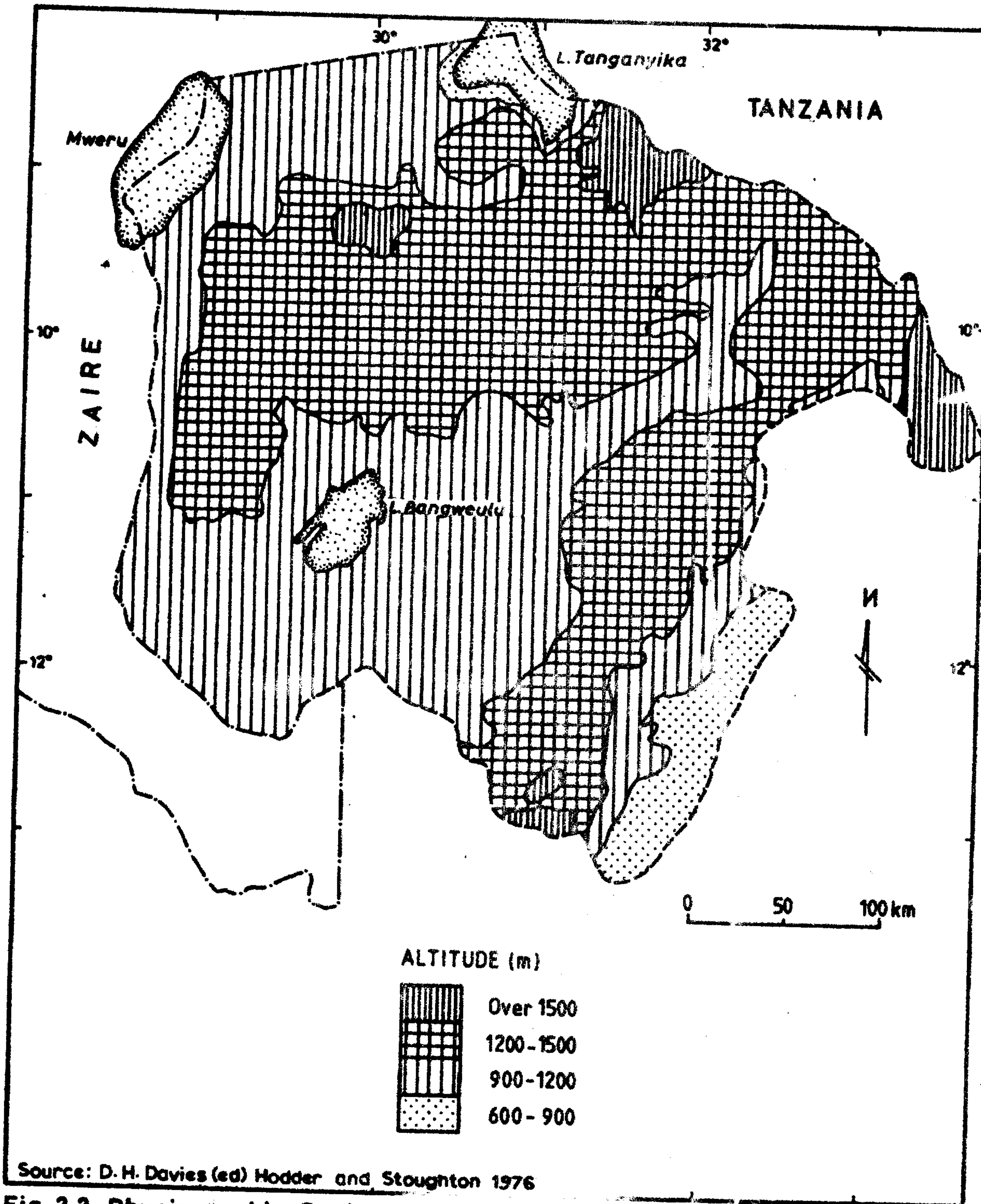

Fig. 2.2 Physiographic Regions of The Study Area.

(ii) Land between 900m and 1200m (e.g. a large area along the Luapula Valley, the area covering most of Nchelenge and Kaputa districts, and the extensive area around and north-east of Lake Bangweulu and along the Chambeshi Valley);

(iii) Land between 1200m and 1500m (e.g. the high plateau areas of Northern and Luapula Provinces);

(iv) Land over 1500m (e.g. the Kawambwa-Mporokoso highlands).

Clearly, the exact ages of Zambia's relief features are subject to various interpretations. Dixey holds the contention that by fairly general consensus, the main plateau of Africa between 1200m and 2000m and higher belongs to the Miocene or Mid-Tertiary age (Dixey, 1955:1). On the contrary, du Toit and Jessen ascribe such surfaces to Cretaceous age (Dixey, 1955:2). Concurring with these two, Archer regards the Mbala area about 1640m above sea level - and one of the oldest surfaces in Zambia, as a Post-Gondwana cycle surface developed during the Cretaceous period (Davies, 1976:14).

The early Tertiary period which followed the Cretaceous period was responsible for forming very flat landscapes over larger areas such as the higher plateau watersheds of the two provinces. But the later Tertiary age resulted in the formation of lower areas, for instance, the Luapula Valley and the main basins such as lakes Bangweulu, Mweru and Mweru Wantipa and the surrounding swamps.

Finally the Karroo period formed the main faulting while

Pleistocene and recent periods have been responsible for the formation of fault scarps and the plateau between Lakes Tanganyika and Mweru (Davies, 1976:14).

Accordingly, in the study area there are significant variations in elevation largely due to faulting, uplift and simple folding. For instance, around Lake Tanganyika, the plateau has been broken by a steep escarpment to form a rift valley floor at an altitude of about 600m. This is clearly displayed by the narrow strip from Mpulungu to Sumbu in Northern Province. Similarly the high plateau watershed of Luapula Province descends by scarp slopes to the Luapula Valley-Lake Mweru trough situated at an average altitude of about 900m (Fig. 2.2).

Furthermore, as George Kay argues, the plateaux have not escaped entirely unscathed from tectonic interference, for there has been some warping of their surfaces. This, coupled with effects of differential erosion, has inevitably interfered with the free drainage (Kay, 1971:19). The obvious result has been the formation of shallow lakes and extensive swamps and flood plains which are inundated annually. Such stagnating water bodies have provided excellent breeding and "nesting" grounds for cholera vibrios in Northern and Luapula Provinces (See Chapter four). In addition such relief variations as discussed here are an important factor in population distribution and hence spatial variation of diseases such as cholera.

Climate is another environmental factor which appears to be responsible for cholera outbreaks in Zambia.

2.03 CLIMATE

Like the rest of Zambia, the climate of the study area is greatly influenced by the general circulation of air masses. The major ones are the South East Trade Winds and the Intertropical Convergence Zone (I.T.C.Z.). Besides these air masses, local topography of the area plays a very significant role in modifying climate.

Two main aspects of climate, namely temperature and rainfall are briefly discussed here:-

(i) Temperature

The elevation of the land in general lowers temperatures over most of the study area as altitude ranges between 600m and 1500m and over. Clouds and showers during the hottest season of the year (i.e. between October and March) have a cooling effect as well. Inversely, lower regions such as the Luapula-Mweru lowland and the narrow lakeshore strip around the southern tip of Lake Tanganyika experience an extremely hot climate between October and March. A mean annual temperature of 27^{o}C in this region is not uncommon. (Fig.2.3) This is ideal temperature for the survival of cholera vibrios.

(ii) Rainfall

The study area is one of the regions in Zambia which receives the highest rainfall. It has a mean annual rainfall of over 1400 mm (Fig. 2.4).

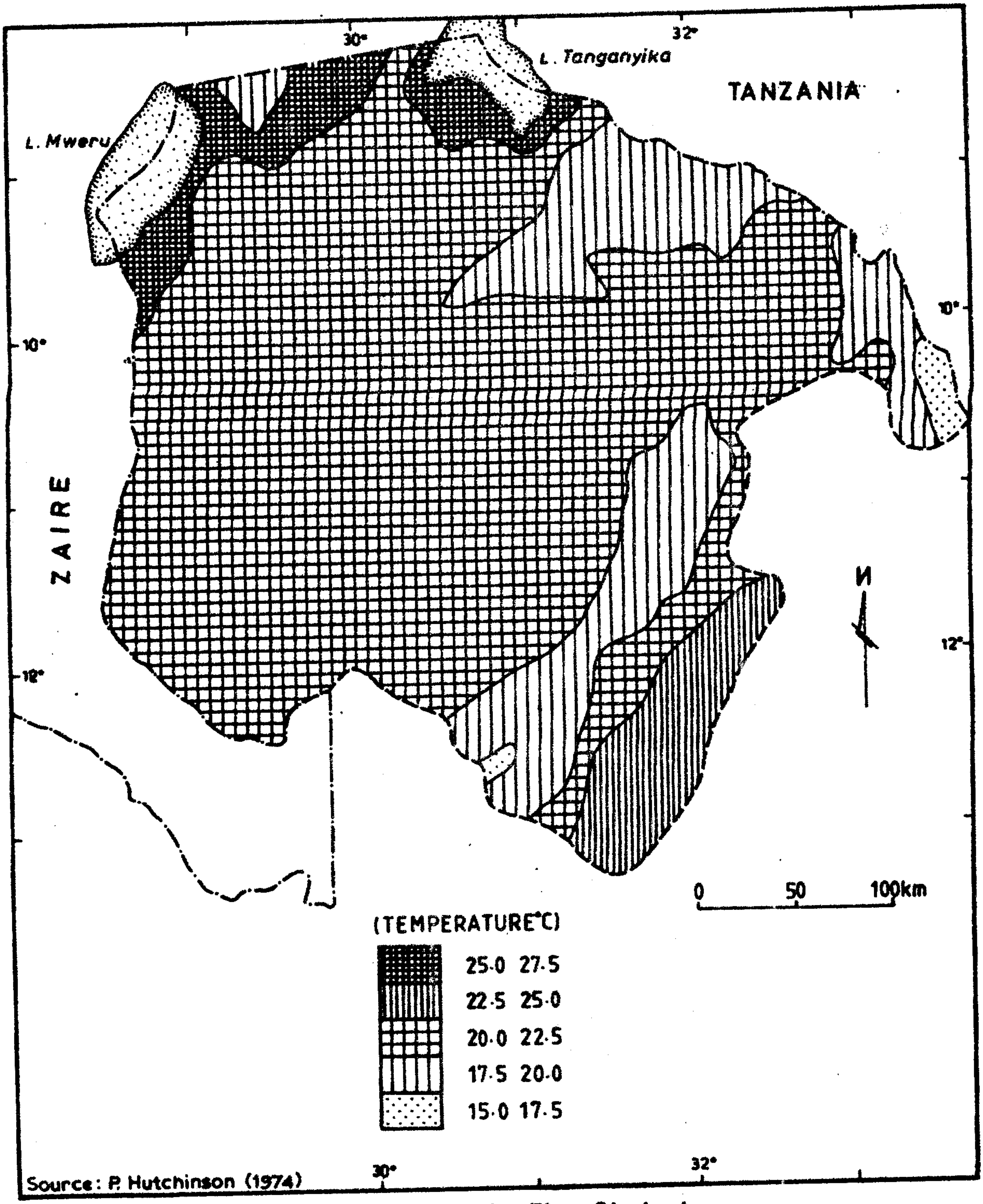

Fig. 2·3 Mean Annual Temperature in The Study Area

The major portion of this rainfall is associated with the movement of the Zaire Air (North West Trade Winds) and the I.T.C.Z. (Hutchinson, 1974:20). The converging of the Zaire Air and the South East Trade Winds results in heavy convergence rainfall. The intensity of the rainfall however varies with variation in relief. As a consequence, highland areas such as Kawambwa, Kasama and Mbala experience significantly high rainfall, while low-lying areas such as the Luapula-Mweru trough receive low rains. Convectional rainfall - particularly around Lake Bangweulu also contributes a reasonable proportion of rainfall. The heavy convectional rainfall around the lake is largely due to the additional atmospheric moisture resulting from evaporation of the water from the lake and surrounding swamps. Notably, the Bangweulu area holds one of the largest inland swamps in the world (Kay, 1971:19).

Although both temperature and rainfall only weakly influence the survival and spread of cholera (see Chapter four), it is abundantly clear that as a man-environment transmission disease, socio-economic factors too play a vital role. Thus it is worthwhile to discuss these aspects as well.

2.02 SOCIO-ECONOMIC SET UP

2.021 The Population Aspect

Population patterns are normally determined by a number

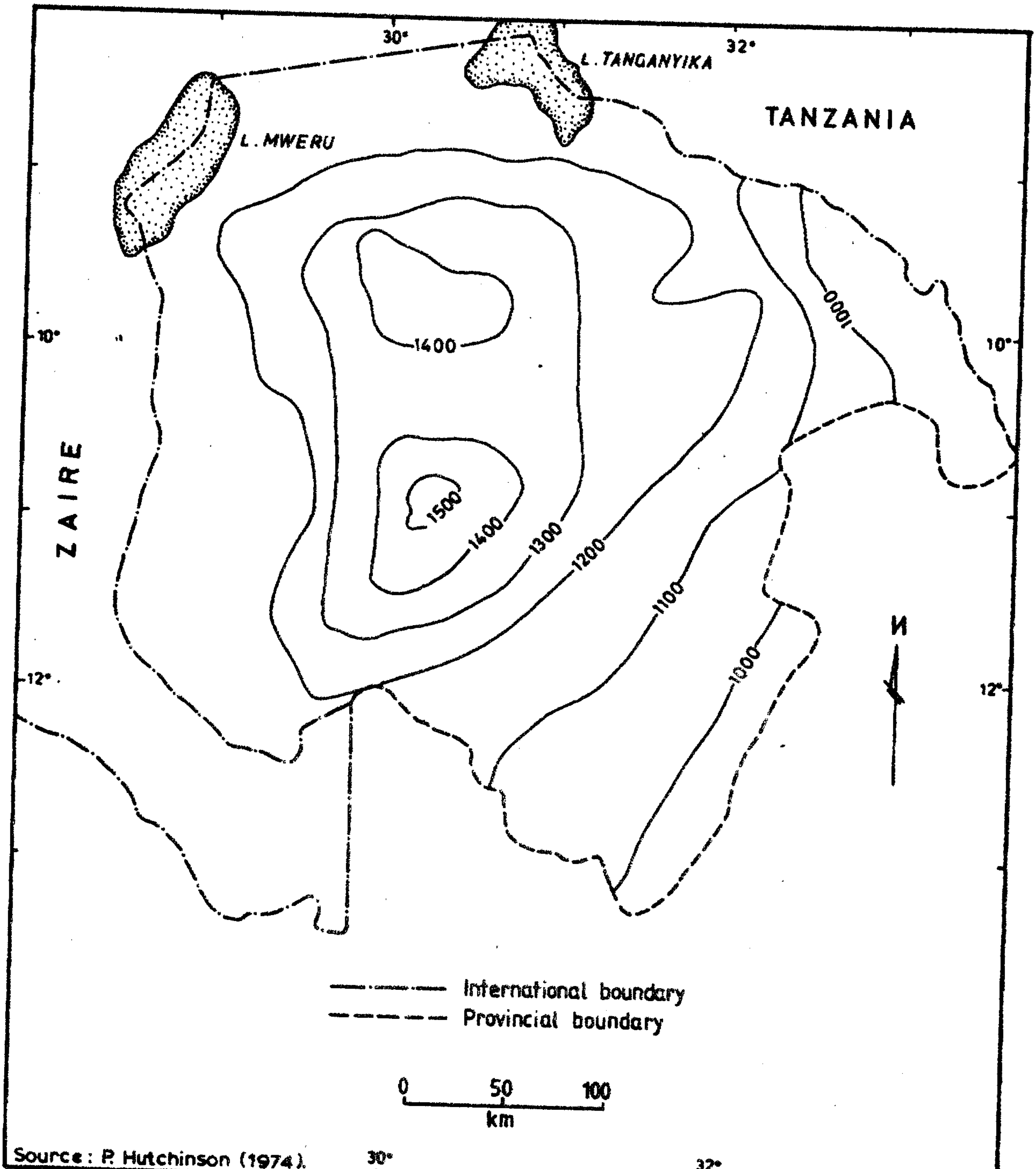

Fig. 2.4 Mean Annual Rainfall in The Study Area

of interacting factors. Among the most important are relief, water supply, soil fertility, historical, cultural and economic forces. It is worth noting that in the study area it is almost impossible, to attribute population distribution to any one of the aforementioned factors. These environmental and cultural factors are so interlinked that they are best dealt with in their totality. However, in order to arrive at some kind of synthesis only probable effects of some of the major factors are discussed here.

The Northern and Luapula Provinces are moderately peopled areas with "islands" or "pockets" of dense population (Kay, 1971:49). These "pockets" of crowded people can be divided into two categories:-

(i) those associated with the important fishing industry of the lower Luapula river, Mweru and Bangweulu lakes and swamps. (A similar concentration is found around Mpulungu on the shores of lake Tanganyika);

(ii) those associated with important local settlements. For example, Kasama and Mansa both of which as Provincial Headquarters, have attracted large populations. Others include Mbala and Kawimbe Mission.

Besides the presence of the fishing industry, the unquestioned importance of water sources during the dry season and limited technology (to develop water supplies), have greatly influenced the dense concentrations of people near perennial water supplies.

Furthermore, in Luapula Province, the dense population in the lower Luapula Valley, historically owes a great deal to the development of a highly organised state which was created by the immigrant Lunda (Kay, 1971:58). The Lunda migrated from Zaire and to date have strong traditional ties with Zaire (see Sub-section 2.023).

2.022 The Economic Aspect

Traditionally most Africans in rural areas of Northern and Luapula Provinces depend directly upon the land as well as water for their livelihood. Consequently most of them have no specialised profession. Depending upon the season, a villager could be a crop cultivator, fishermen, hunter and so forth. Through such multifarious activities, a villager exploits a wide variety of resources for subsistence. Presently however, there is a growing tendency towards professionalizing the fishing industry. But this is still in its embryonic stage.

Nonetheless it is a fact that the development of the fishing industry - especially in Luapula Province acceletated the accumulation of money in the rural economy. As Musambachime (1981:4) contends, this steady flow of money gave the fishing communities and traders the opportunity to develop a propensity to save, invest in retail businesses, and to build brick houses. In fact, Luapula Province has more than 80 per cent brick dwellings of all rural dwellings while Northern Province has between 20 and 59 per cent brick dwellings (Davies, 1976:63). This indicates an attainment of a higher standard of living regarding housing in the two Provinces. Hence cholera could only have broken out as a result of other factors, and not as a result of poor housing.

In both Provinces the dense rural population depend heavily on cassava as their staple food. Cassava, a drought-resistant crop is most ideal in such areas of infertile soils. In addition, cassava cultivation requires less attention and simple methods of cultivation. This is especially advantageous in an area of polyfunctional (multifarious) type of life as is common in the study area. Furthermore, cassava is able to support a larger number of people per unit area than any other crop in such infertile soils (Kay, 1971:54). In this respect cassava has surpassed such grain crops as millets and sorghums. Although with a lower protein-content cassava meals are supplemented by fish in the crowded lakeshores and islands, on river banks and edges of swamps.

2.032 The Political Aspect

The study area is bordered by Zaire to the West and North and Tanzania to the North-East. Because of the Shaba (Zairean) pedicle, from the point of view of accessibility, Northern and especially Luapula Provinces appear to be remotely connected with the rest of Zambia.

It is important to note that political boundaries in Africa were created by European colonialists during their scramble for Africa in the nineteenth century. Technically boundaries are arbitrary and imaginary superimpositions separating two states. In the process, political boundaries disregard tribal or cultural homogeneity. They pass through lands -

dividing villages and ethnic groups, grazing lands or even kingdoms, nations and lakes.

The obvious result is that clans and families have been divided and made to belong to different political entities, called nations. Even where there is a natural physical boundary such as the Luapula river with one ethnic (Lunda) group on either side, the people have been politically divided. But the people themselves are very strongly tribally interwoven. Their common ethnicity and homogeneity is usually strengthened through intermarriages and trade or through accession to the throne of the Lunda people. In this respect, for instance, Chief Kazembe of the Lunda in Luapula Province pays homage to a Paramount Chief on the Zairean side of the Luapula river. Similarly the people of Kaputa, Mbala and Isoka districts of Northern Province have equally strong ethnic connections with people inhabiting the other side of the border in Zaire or Tanzania.

It is such intimacy and consequent population mobility that could have facilitated the transmission and diffusion of cholera into Zambia from neighbouring countries. Infected persons from either Zaire or Tanzania make unchecked frequent trips to Northern and Luapula Provinces. Thus, from time to time these migratory people have tended to provide a reservoir for cholera, as very little seems to have been done (in terms of control and spread of cholera) on the other sides of Zambia's borders.

CHAPTER THREE

3.00 THE EPIDEMIOLOGY OF CHOLERA

The term "cholera" is probably derived from the Hebrew word "Kholira" meaning bad pain or from the Greek word "cholēra" meaning roof or gutter (Felsenfeld, 1967:4). Whatever its genesis, cholera is generally associated with severe and copious diarrhoea and poor sanitation. It is an endemic or epidemic diarrhoea which is often accompanied with vomiting and muscle cramps but with little abdominal pain (Felsenfeld, 1967:4).

3.01 THE NATURE OF CHOLERA

As has been said in the preceding paragraph, cholera is an acute intestinal infection which is caused by a specific bacterium, the *Kommabacillus* of Koch (De, 1961:1) named after the German bacteriologist Robert Koch who, in the course of examining the intestines of a cholera victim in 1883, discovered the cause of cholera (Jusatz, 1977:131). The comma-shaped bacterium is called *Vibrio cholerae* and measures about 4.0 x 0.03 microns (Misra, 1970:97). The causative bacterium is thus a very tiny micro-organism. In recent times, cholera has also been known to be caused by *Vibrio El Tor*, a biotype[1] of *Vibrio cholerae*. Either type however, shows profound endeminity and epidemicity.

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1. A biotype is a group of organisms or individuals having similar hereditary traits.

With complex chemical and morphological structures cholera vibrios can, on the basis of their antigenic properties, be classified into three main serotypes[2] (Pollitzer, 1959:684-6). These are Inaba, Ogawa and Hikojima. Although Misra (1970:97-82) discussed El Tor as a serotype, scholars such as Felsenfeld (1967:4), De (1961:1-2), Barua and Burrows (1974) generally regard it just as a biotype.

In the present study El Tor will be treated as a biotype with the same serotypes (i.e. Inaba, Ogawa and Hikojima as V. cholerae. The reasons for treating El Tor this way is because of the difficulty in distinguising with certainty between V. cholerae and El Tor, particularly in Africa which has been affected by the El Tor pandemic. However, the El Tor type is the more aggressive strain. Its aggression is not so much in the virulence with which it attacks but in its apparent capacity to survive and travel in less conducive conditions for cholera vibrios in this modern hygienic world (Times of Zambia, October 28, 1974:4).

In the transmission of cholera man is the prime and only known natural host of the V. cholerae. It is man who acts as a breeding medium as well as carrier of the cholera vibrios. The germs (vibrios) multiply in the intestines of the cholera patient and are ultimately excreted through his/her faeces. The V.cholerae may then contaminate the soil, water supply or food. Inevitably, then, the ingestion of any such contaminated media, significantly facilitates the transmission of cholera. Besides cholera transmission through infected water supplies,

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2. A serotype is a microbiological term referring to intimately related micro-organisms distinguished on the basis of antigenic composition.

soil or food, the vibrios can also spread through direct contact of the victim's body, clothes or utensils.

Apart from man (as both pathogen and geogen), there are significant environmental factors facilitating the survival and spread of cholera. These are discussed at length in Chapter four. In brief, such geographical factors, include warm annual temperatures of around 37°C (Misra 1970:97) and prolonged dry spells. Moisture is another important factor. Cholera vibrios thrive best in warm alkaline media (with a pH value of between 9 and 9.6) while acidic media inhibit their growth and survival.

Dr. John Snow further included water containing organic matter and salts; areas sheltered from the sun's rays; and congregations of susceptibles in some areas (Stamp 1964:36). It was Snow who in fact found the real answer to the cause of cholera in central London in 1854 (Fig. 3.1). In his study, Snow mapped all the 500 deaths due to cholera in the Soho district and marked the stand water pumps in the area. In the final analysis he discovered that most of the cholera cases clustered around a communal manual pump in Broad Street. He accordingly correlated the cholera outbreak in Soho district with contaminated drinking water. Thus when the handle of the water pump was removed at Snow's request, no new cases were reported (Stamp 1964:36).

Man aside, such secondary sources as food (for instance Kapenta[1] from Mpulungu and Sumbu to consuming areas

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1 Kapenta are a small sardine-like fish found in Lake Tanganyika.

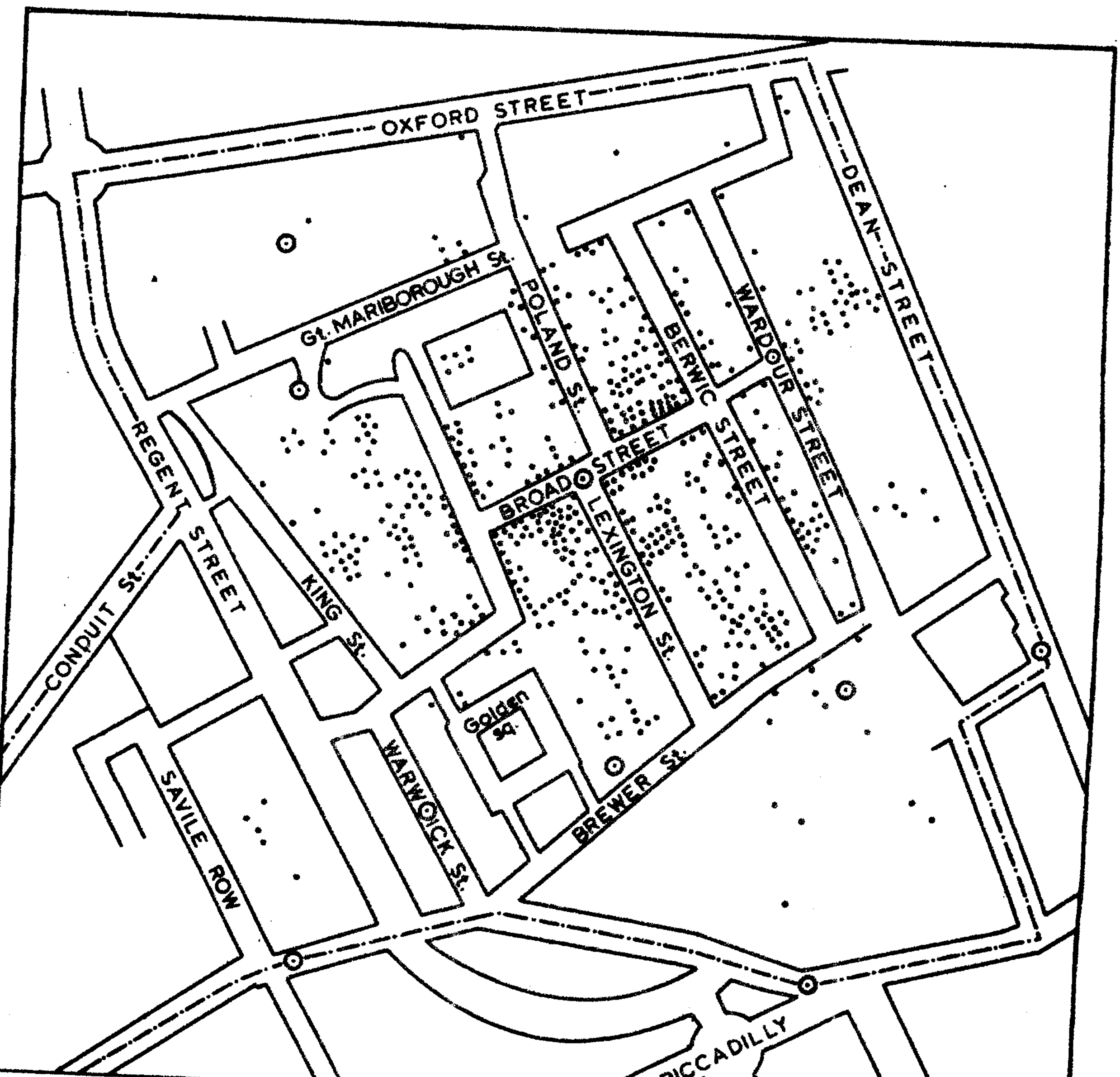


Fig. 3·1 John Snow's Map of Cholera Deaths in The Soho District of London, 1854.

∴ Deaths from Cholera
⊙ Pump

0 90 180 m

rce: L. D. Stamp (1964) The Geography of Life and Death, London, Fontana p. 35.

on the Copperbelt and Lusaka) may carry the disease as cholera epidemics spread out. Even flies may directly carry cholera vibrios to the food from contaminated media - especially soil. Flies are known to carry cholera vibrios from contaminated night soil, used as manure in vegetable gardens. The transmission of the disease is particularly effective when the vegetables are eaten raw.

3.02 THE CLINICAL SYMPTOMS OF CHOLERA

H.J. Jusatz contends that 'cholera has the shortest incubation period of any infectious disease' (1977:131). When infected the patient may begin to show severe symptoms of the disease within a few hours of the infection. Such grave symptoms sometimes occur on the first day or within the first five days of the infection.

A typical attack of cholera is usually characterised by an abrupt onset of severe and profuse diarrhoea with rice-water stools (Jusatz, 1977:129). This voluminous discharge occurs with ever-increasing frequency and may be accompanied with vomiting. According to Felsenfeld (1967:58), at least 80 per cent of the cases are accompanied by vomiting. The obvious result of such profuse diarrhoea and vomiting is tremendous loss of tissue fluid and salts from the body and skin.

Other symptoms may include clammy skin (that is, washer woman's fingers as described by S.N. De, 1961:2), sunken eyes and cheeks and a drop in both body temperature and blood pressure. The general effects are:-

(a) dehydration;

(b) rapid respiration; and

(c) cramps and a marked salt-content depletion.

Shock and collapse might be added complications and death is imminent in most cases.

Thus if not treated within the first 3-7 days of its infection and given the aforementioned clinical symptons, cholera outbreaks may result in mortality of around 60 per cent or even higher of the cases (Jusatz, 1977:132). But prompt action in the form of treatment through rehydration, the use of antibiotics and application of quarantine measures to prevent the multiplication and spread of cholera may reduce mortality to as low as 2.0 per cent (Jusatz, 1977:132) or even to nil (Stock, 1976:9).

It must be noted, however, that not all cholera cases display such clinical symptoms as discussed above. Some patients may not even show signs such as severe diarrhoea or vomiting at all but may be perfectly excellent carriers of cholera. For instance, there are carriers who have been infected by V. cholerae, but do not show any positive signs and may thus reinfect the environment unknowingly.

Generally there are several types of carriers who may broadly be classified as follows (Stock, 1976:9):-

(a) Incubatory (that is those that are infected and later display clinical symptoms);

(b) Convalescent (that is those that excrete vibrios during their recovery period);

(c) Symptomless (that is those that generally excrete vibrios, but do not develop any clinical symptoms).

Furthermore, it is important to note that the carrier period or state varies with the different serotypes of *V. cholerae*. For instance, the normal *V. cholerae* in most cases lasts only up to five days, but cholera El Tor may last up to as long as 15 days. In fact the carrier or incubation period may occasionally be longer (Pollitzer, 1959:684-6). For instance "cholera Doleres" endemic in the Philippines has been known to have a carrier period of up to ten years (Stock, 1976:9). It is a fact that one Philippino woman has been known to have been excreting cholera vibrios for more than eight years (Stock, 1976:9).

3.03 CHOLERA IN AFRICA, 1970-1981

The present cholera pandemic which Stock (1976:15) considers to be the seventh while Jusatz (1977:133) contends should be the eighth, has affected some seventy-five countries in Asia, Africa and Europe. The present study considers this cholera pandemic as the seventh because since the sixth cholera pandemic of 1899-1923 (Table 3.1), no other cholera pandemic seems to have been recorded to this author's knowledge. This pandemic originated in Sulawesi (Celebes) in 1943 and appeared to have stagnated there until 1961. From Sulawesi it spread to other parts of South

TABLE 3.1: EXTENT OF THE FIRST SIX CHOLERA PANDEMICS

PANDEMIC	DATE	INDIAN SUB-CONTINENT	SOUTH-EAST ASIA	EAST ASIA	MIDDLE EAST	S. EUROPE	N.W. EUROPE	N.E. EUROPE	NORTH AFRICA	EAST AFRICA	W. AFRICA	NORTH AMERICA	CENTRAL AMERICA	SOUTH AMERICA
FIRST	1817-23	x	x	x	x					x				
SECOND	1826-37	x	x	x	x	x	x	x	x	x		x	x	x
THIRD	1842-62	x	x	x	x	x	x	x	x	x		x	x	x
FOURTH	1865-75	x	x	x	x	x	x	x	x	x	x	x	x	x
FIFTH	1881-96	x	x	x	x	x	x	x	x	x	x	x	x	x
SIXTH	1899-1923	x	x	x	x	x		x		x				

x denotes the occurrence of the cholera during a Pandemic in a particular geographical area.

SOURCE: R.F. Stock (1976) Cholera in Africa: African Environmental Report, 1976 p.15

East Asia, but apparently to no other continent (Fig. 3.2).

According to Adesina (1982:312), the present cholera pandemic was brought to West Africa in the early 1970s from Asia, most probably by students travelling home by air. This would explain its quick and sudden appearance and spread in West Africa. Considering the speed at which cholera overran West Africa Adesina ascribed the outbreaks and spread to the process of spatial diffusion. Stock (1976:36-50) offering a more detailed and comprehensive analysis of the cholera outbreaks in West Africa, identified four types of cholera diffusion processes (see Chapter five).

Discussing what he terms coastal diffusion, Stock (1976: 36-42), maintains that cholera in West Africa was initially introduced into fishing villages whence it diffused to other fishing villages before diffusing into the interior. Thus interior urban centres were infected from the coast.

Another diffusion process Stock looked at was riverine. This is also known as "linear diffusion" in which he described the diffusion of cholera as showing a linear configuration especially along the middle of the Niger Valley. He further discussed at length urban hierarchical and radial contact diffusion models. Radial - contact diffusion model (see chapter five) is similar to Hagerstrand's expansion diffusion model where the disease remains in its endemic area but keeps sending out epidemic waves at intervals.

Thus in general Stock highlighted the possibility of epidemics being channelled in certain directions to later

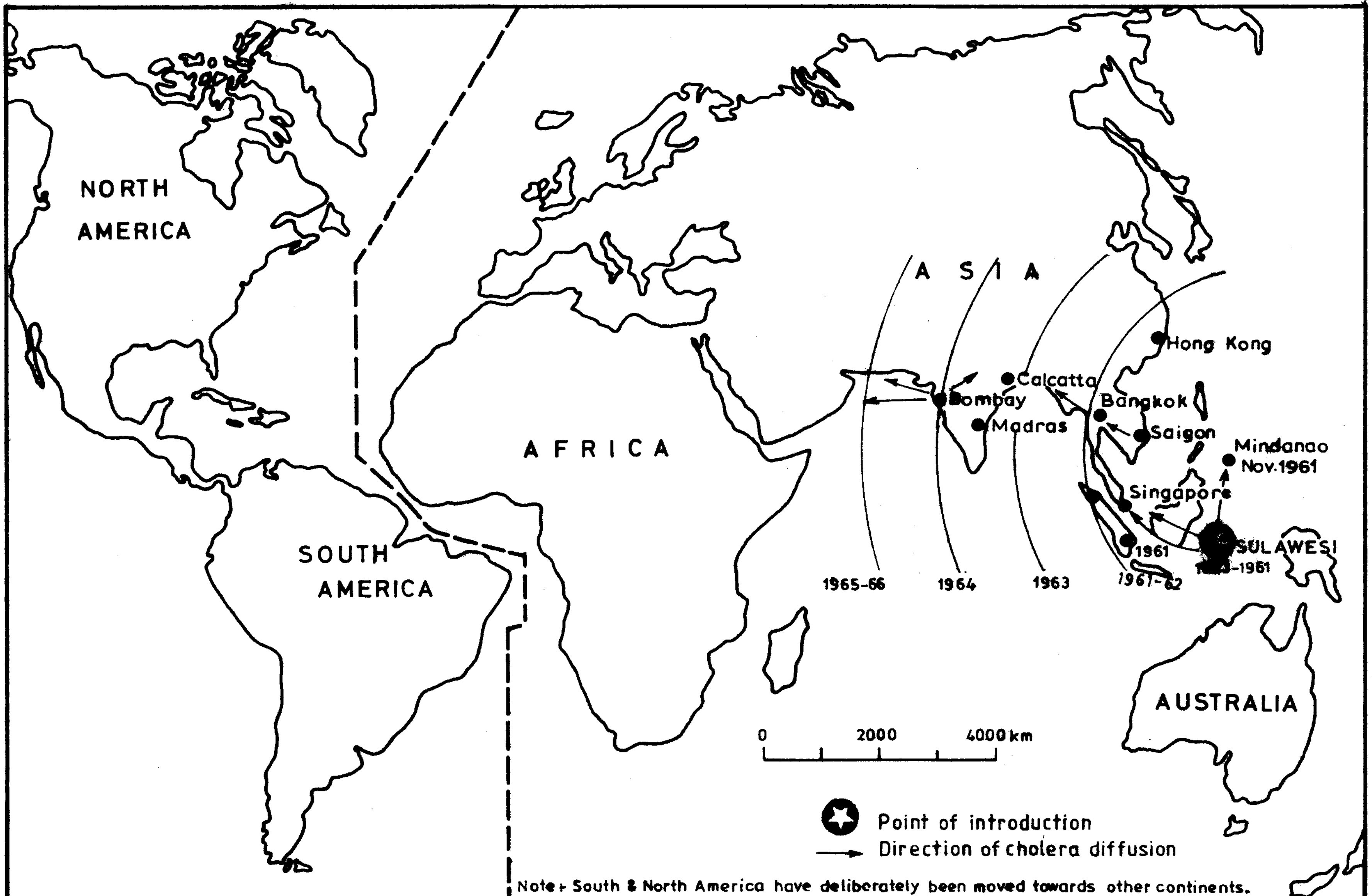


Fig. 3·2 CHOLERA EL TOR PANDEMIC After Bhatty, 1967. Source: Compiled by the Author from:- H. J. Jusatz "cholera" in G.M. Howe (ed.) A World Geography of Human Diseases, 1977, p. 143

expand into susceptible areas (Jusatz, 1977:142). Besides, West Africa, Stock also discussed briefly other cholera reporting areas of Africa, such as parts of the Horn of Africa, South-East Africa and South West Africa.

Kwofie (1976:127-130) also studied the spatial diffusion of cholera outbreaks in West Africa during the period 1970 and 1971. He concluded by summarizing that the spatial patterns of cholera were responses to interrelated factors such as nutrition and health, environmental sanitation, overcrowding and drought. Undoubtedly in Zambia all these factors militate against health while facilitating the outbreaks and spread of such diseases as cholera.

Table 3.2 (Appendix III) shows that cholera has been present in countries neighbouring Zambia for over a decade, although Zambia herself apparently remained unscathed by the disease, until October, 1978. Angola was first struck with cholera in 1971; followed by Mozambique (1973), Malawi, Tanzania and Zimbabwe in 1974 (W.H.O. Statistics: 1971-1981). But because disease epidemics recognise no political demarcations, Zambia was bound to be affected soon.

3.04 CHOLERA IN ZAMBIA, 1970-1978

In Zambia the first cholera outbreaks were reported during the month of October, 1978. Before this, during 1973-1975, there had only been reports of scattered occurrences of cholera in Eastern Province - possibly imported from Mozambique and/or Malawi. It is interesting to note that while all of Zambia's neighbours - Angola, Zaire, Tanzania, Malawi, Mozambique and Zimbabwe were extensively affected by the disease during the early 1970s, Zambia apparently remained unaffected. There appears to be no information available to explain this situation.

It is apparent however that there was a great deal of under-reporting. Alternatively, there might have been no serious cholera outbreaks to warrant the formation of cholera surveillance committees which normally report such outbreaks of the disease.

CHAPTER FOUR

4.00 SPATIAL AND STATISTICAL ANALYSES OF CHOLERA DISTRIBUTION IN THE TWO PROVINCES

Chapters one, two and three were concerned mainly with a general discussion of the subject of Medical Geography; a brief description of the study area and a consideration of the epidemiology of cholera. This chapter concerns itself with the analysis of social and geographical (spatial) factors which might have influenced the outbreaks and diffusion of cholera in the two provinces under study.

Cholera epidemics were first reported in Northern Zambia in October 1978. Since then there have been two main epidemic waves of the disease resulting in about 2047 cholera cases and more than 200 deaths.

The first outbreak reported in Northern Province around 27th October, 1978, most probably originated from Tanzania or Zaire along the lake. This cholera infection was introduced at Sumbu fishing village between 21 and 24 October 1978. From here it diffused through water (i.e. by boats and canoes) eastwards to other fishing villages of Kasaba, Yendwe, Kapembwa, Mwela and those surrounding Mpulungu port on Lake Tanganyika. From the lakeshore, cholera diffused into the interior - westwards into the Kaputa area reaching it by 30th October, 1978. Eastwards the cholera infection diffused into Mbala around mid-November 1978. Kasama with two cases was struck by the disease about 30th December 1978.

After a period of comparative abatement and quiet during the month of January, 1979, a minor epidemic - endemic in the fishing villages surrounding Mpulungu port - broke out in February, 1979. Although there appeared to be fresh infusions of the disease by lake from Zambia's Northern neighbours, this minor outbreak was basically a continuation of the first major one. By the end of 1982 more than 630 cholera cases had been reported from Kaputa and Mbala districts of Northern Province.

The second major cholera epidemic occurred simultaneously in the villages of Lukwesa and Kawama in Luapula Province on 23 December 1981. This outbreak was most certainly introduced from Zaire (see Chapter five). From the points of introduction at Lukwesa and Kawama the cholera infection diffused upstream reaching Mambilima around 25 December 1981. It also diffused downstream by boat, reaching Nchelenge and Kashikishi about the 6th January, 1982. By the end of March, 1982 most of the Luapula Valley and Lake Mweru lakeshore areas had been affected by the cholera infection. Like in Northern Province, this major outbreak was followed by a period of abatement until September, 1982, when there was another minor and less severe outbreak from Pweto situated on Zambia's northern border with Zaire. The Pweto outbreak stagnated in Mununga area and resulted in yet another minor outbreak of 1982-1983. Accordingly by the end of December, 1982 more than 1417 cholera cases had been reported from Luapula Province alone.

4.01 SEASONAL DISTRIBUTION

The two main cholera outbreaks in Northern and Luapula Provinces have been introduced during the period from October to December. This is the peak period for the hot and dry season in the country. There appears therefore, to be a strong tendency to ascribe the flunctuating cholera incidence to changes in temperature.

Moreover, the hot and dry season in the two provinces appears to be most ideal for the proliferation of V. cholerae, particularly in the surface water supplies such as lakes, swamps and wells. Contrary to this Pollitzer (1959), contends that the length of survival of the V. cholerae is apt to show a decrease with increasing temperature rather than an increase, probably because at such high temperatures it is too hot for the cholera organisms to survive. In fact Adesina (1981) working on cholera diffusion in Nigeria has statistically shown that there is only a weak positive relationship between temperature and cholera incidence.

This implies that other environmental factors (and not necessarily temperature) must be responsible for the high incidence of cholera in Northern and Luapula Provinces at that time. Perhaps one of the most important factors is the source and type of drinking water.

4.02 The influence of type of domestic water supplies on the outbreaks of cholera

Cholera is a disease whose best medium and means of survival and transmission is water. Therefore in order to minimize its spread people must be provided with safe and protected drinking (or domestic) water supplies. Table 4.1a shows the sources of domestic water in cholera - affected areas. The table was compiled from responses of a sample of surviving cholera victims.

From the table (4.1a), 10 per cent of the respondents drew their drinking water from rivers while a staggering 55.3 per cent got their water supply from either streams or wells. Most of the wells are often dug in the bed of streams. Other wells are dug in river valleys beside the stream while yet others may be dug in areas with low water table. These latter wells require the use of buckets and ropes to draw the water. Thus a cholera-contaminated bucket or rope owned by one family could be a possible cause of cholera contamination for a whole homestead or village. The former type of wells in the stream beds are often shallow and unprotected. These areas too are susceptible to cholera contamination.

Still from table 4.1a, 28 per cent of the cholera survivors obtained their domestic water from lakes, while 4 per cent obtained their water supply from protected or unprotected boreholes and only 0.7 per cent got their water from open ditches. Accordingly 98 per cent of the cholera victims drank untreated water. Only 2 per cent had access to piped water at Mpulungu, Kashikishi, Nchelenge, Mwense and Mbala. Generally these findings concur with those done in

TABLE 4.1a **SOURCES OF DRINKING WATER**

Water Sources	Absolute Frequency	Percentage
River	15	10.0
Lake	42	28.0
Borehole	6	4.0
Piped Water	3	2.0
Well/Stream	83	55.3
Ditch	1	0.7
TOTAL	150	100.0

TABLE 4.1b **WATER SOURCES**

Serial Number	Water Sources	Test Group		Control Group	
		Number	Percentage	Number	Percentage
1	River	37	8.4	18	13.74
2	Lake	129	29.19	-	-
3	Stream	41	9.28	56	42.77
4	Well	202	45.7	61	46.56
5	Ditch	36	8.1	3	2.29
6	Spring	-	-	2	1.53
7	No answer	13	2.9	1	0.7

Source: V.J. Mahadik and J. Mbomena "Impact of Health Education Programme on KAP of cholera affected areas of Luapula Province, Unpublished Paper

Luapula Province by Mahadik and Mbomena, (Table 4.1b).

Over and above this, it is a widely known fact that due to the high evaporative effect of the heat during the hot and dry season people tend to consume more water. But this is also the period when the levels of water in the streams and wells are the lowest. The streams become sluggish and may cut off portions to form swamps or lagoons. Such brackish water becomes excellent "nesting" grounds for cholera germs. Thus coupled with a greater thirst for water and locally brewed sweet and intoxicating beers (often brewed with water from contaminated sources) during the hot and dry season, even a slight water contamination soon results into cholera incidence. Consequently, higher cholera occurences were reported during the hot and dry season, than at any other time.

Furthermore, even some of the piped water may not necessarily be safe for drinking. At Nchelenge and Kashikishi for instance, water is pumped from the lake through pipes into reservoirs. There appears to be no purification process followed. From the reservoirs the water is distributed directly for consumption. In both places, the pipe-ends for water in-take are barely a few metres from the lakeshore. This gives easy access to impurities and even faeces often deposited in water and sandy lakeshores. Such conditions certainly contributed to the high incidence of cholera at Nchelenge (556 cases) and Kashikishi (217 cases).

4.03 The Influence of Excreta Disposal on the Outbreaks of cholera

From Table 4.2, it can conclusively be stated that most of the cholera victims (67.3 per cent) use pit lavatories (or latrines). This compares favourably with the control group (89.33 per cent). A significantly sizeable number of cholera victims (28.6 per cent) still defecate in the bush and/or water. Non-cholera victims on the other hand only comprise some five per cent of the control group who defecate in the bush and/or water. The high percentage of those defecating in the bush and/or water among cholera victims inevitably led to faecal contamination of the soil and water supplies. This would explain the high cholera incidence among fishing communities.

Further, although most of the pit latrines were more than two years old, there is a strong possibility that during the first cholera outbreaks in the years from 1978 to 1981 many people had either no pit latrines or used very old latrines. Such unhygeinic conditions could undoubtedly have facilitated the occurrence and rapid spread of the disease. This could probably have been done by flies transmitting the disease germs from contaminated latrines to the food.

In addition the cholera epidemics were worsened further by inadequate refuse disposal methods (Table 4.3). It is discernible from the table that although more than half (58.0 per cent) of the respondents in the test group used refuse pits, these were in most cases very close to the

TABLE 4.2 LAVATORY TYPES

Types of Lavatory	TEST GROUP		CONTROL GROUP	
	Frequency	Percentage	Frequency	Percentage
Pit Lavatory	101	67.3	134	89.33
Flashing Lavatory	6	4.0	9	6.00
Use of Bush/Water	43	28.6	7	4.67
TOTAL	150	99.9	150	100.00

TABLE 4.3. REFUSE DISPOSAL METHODS

Types of Refuse Disposal	TEST GROUP		CONTROL GROUP	
	Frequency	Percentage	Frequency	Percentage
Open Pits	87	58.00	107	71.33
Dumped near house	59	39.34	38	25.33
Municipality collection	4	2.67	5	3.33
TOTAL	150	100.01	150	99.99

houses and most of them were nearly full. The control group revealed that more than 71 per cent used refuse pits while another 25 per cent just dumped their refuse near the house. Compared with the test group's 39.0 per cent, this would imply that nearly filled refuse dumps near houses contributed to the spread of cholera. In this respect it is very likely that cholera outbreaks were influenced by both contaminated latrines and refuse dumps.

Another important factor about the cholera victims, according to this study, was the occupational structure of the victims which played a very significant role in cholera outbreaks (Table 4.4). Fishermen, fish traders and generally poor people exposed to poor sanitation were severely affected. An analysis of the occupational structure reveals that out of a sample of surviving victims, 36 per cent were fishermen while about 14 per cent were fish traders. About 6.7 per cent indicated that they were general hawkers while 18.7 per cent were housewives. Some 8.7 per cent were school children and 14 per cent were engaged in peasant farming.

Although with a clear bias towards water associated occupations (making up to 50 per cent), cholera can attack any one belonging to any social and/or occupational class. However, in general fishermen, fishmongers, housewives and peasant farmers contributed the largest number of victims (about 83 per cent).

TABLE 4.4 OCCUPATIONAL STRUCTURE OF CHOLERA VICTIMS

Occupation	Absolute Frequency	Percentage of Sample
Fishermen	54	36.0
Fish Mongers	21	14.0
General Traders	10	6.7
Housewives	28	18.7
School Pupils	13	8.7
Peasant Farmers	21	14.0
Not applicable	3	2.0
TOTAL	150	100.1

4.04 The Influence of Geographical factors on the Outbreaks and Diffusion of cholera

The main geographical factors that might have been responsible for the outbreaks and diffusion of cholera in Northern and Luapula Provinces include:-

(a) Population density,

(b) Riverine or lake environment, and

(c) Urban importance.

4.041 The effect of Population density on the incidence of cholera in the study area

Spearman's rank correlation technique (Appendix IVA) was chosen as suitable for testing the relationship between two interval scaled variables - cholera cases (relative values) and population density because the data were found to be varied and scattered with sporadic cholera incidence rates. Under the assumptions:-

Ho: There is no significant relationship between high population density and high cholera incidence in the two provinces.

H_1: There is a significant relationship between high population density and high cholera incidence in the two provinces, the following result was obtained:

$$rs = 0.0919$$

This shows a very weak but positive relationship. Thus if most cholera cases appeared to have been reported from high population density areas, it was as a result of other factors such as contaminated sources of water supplies and poor sanitation. High population density only affected the outbreak and spread of cholera very weakly. Another factor that might have contributed to the low Spearman's result is that only few centres of dense population genuinely and correctly reported the occurrences of cholera.

4.042 The effect of Riverine and/or lake environment on the outbreaks of cholera (Appendix IVB)

A student's t test was chosen as most suitable to test this relationship because it is only this one which best tests a data set for the difference between means. The data set of 23 cholera reporting areas was grouped into two samples. Sample I comprised cholera - affected areas near the river and/or lake while Sample II consisted of cholera affected areas away from a river and/or lake. The means were computed and testing for homoscedasticity between them, a t - test for the difference between means of the samples with an equal variances was applied. The calculated t - value (3.98) was significant at 0.010, 0.005, 0.025 significance levels with 10.5 degrees of freedom. From this finding it was conclusively stated that areas closer to a river or lake tended to have higher cholera occurrences. Thus the riverine environment in this study was very significant in the outbreaks and diffusion of cholera, particularly along the Luapula river and the lakeshores of Mweru, Mweru Wantipa and Tanganyika.

This contention was also effectively confirmed by the use of a non-parametric test, the phi-coefficient for "presence" and "absence" of cholera on one hand, and river and/or lake on the other (Appendix IVC). The resulting chi-square (X^2) value of $X^2 = 6.03$ was significant at five per cent (0.050) significance level. This showed a strong association between cholera occurrence and the presence of a river and/or lake. Unfortunately the phi-co-efficient test does not show the intensity of cholera incidence.

4.043 The effect of urban importance on the outbreaks and diffusion of cholera

In this study urban importance was computed by assigning scores of a facility out of 100. It was found that market or commercial centres such as those found at Nchelenge, Kashikishi, Mununga, Mbereshi, Kaputa and Mpulungu tend to attract large numbers of people. A sizeable number of these people are fish-traders and general hawkers. To these are added smugglers of goods across the borders with Zaire and Tanzania.

In Luapula Province, for instance, more than 95 per cent of the bottled beer drunk is a lager called Simba which is smuggled in from Zaire. The smugglers might have been infected with cholera. Thus their intermingling with susceptibles in market and other public places, facilitates the transmission of the infection - culminating in higher cholera incidence in such nucleated centres.

The Table in Appendix IVD attempts to compare which one of the factors: Population density, the type of road through cholera affected areas, urban importance, and riverine environment - is most significantly correlated with the incidence of cholera. Accordingly the simple correlation technique was chosen as a most suitable test for these relationships. The following results were obtained:-

r01 = 0.2788, indicates that the relationship between cholera cases and riverine/lake environment is a slight positive one;

r02 =-0.1339, denotes the relationship between cholera incidence rates and population density. This is a weak negative relationship - resulting most probably from underreporting or non-reporting of cholera incidence;

r03 = 0.0245, depicts the relationship between cholera incidence rates and urban importance Index. This again is a weak positive relationship;

r04 = 0.2244, describes the relationship between cholera incidence rates and the type of road that passes through a cholera - affected area. This is a slight positive relationship.

Thus with scattered and sometimes inadequate data on cholera incidence rates, as has been the case in this study, it is difficult to come up with reasonably strong relationships. Non-reporting and underreporting are most probable reasons for such weak relationships. But weak as they may be, these relationships in close association with socio-economic factors facilitated the outbreaks and diffusion of cholera.

Another student's t test was employed to examine the effects of the type of road passing through cholera-affected areas. (Appendix IVE). Twenty-three cholera-affected areas were divided into two groups - those in Road Type A (with a road score of 0-2); and those in Road Type B (with a road score of 3-5). The means and the difference between means with similar variances were calculated. It was observed that there was no significant difference between the means and variances. The calculate t test = 0.1443. This was insignificant although areas with better roads seemed to have a tendency to have higher incidence. Thus the relationship between cholera incidence rates and the type of road passing through cholera - affected areas is weak. Cholera cases tended to be sporadically distributed, - especially in rural areas with poor sanitation.

CHAPTER FIVE

5.00 THE DIFFUSION OF CHOLERA

Cholera is endemic in South East Asia. For some four centuries, the principal endemic area has been the delta of the Ganges - Brahmaputra Rivers in the Indian sub-continent. Pollitzer (1959) traces cholera in this endemic area to as early as the Sixteenth century A.D. The disease remained endemic in this area of the sub-continent during most of the sixteenth century, although a few outward diffusion waves were not uncommon. For instance, there was one eastwards into China and another westwards into Ethiopia (Stock, 1976:12). Besides, there appears to have been no other recorded outbreaks until Mid-nineteenth century (Fig 5.1).

The first severe epidemic which became a pandemic, diffused out of the Indian sub-continent in 1816 into South East Asia and East Asia, as well as westwards into the Middle East. Since then there have been seven pandemic - six of which occurred during the nineteenth century and one in the twentieth century (Table 3.1). As already discussed in chapter three the cholera epidemics of the nineteenth and twentieth centuries have largely been in the form of great diffusion waves from South East Asia to Europe, Africa and occasionally to North and South America. In the recipient areas cholera has often localised itself in certain "favourable" areas which then become endemic foci. Such areas have emerged in Africa since the 1970s. Among such notable epidemic zones are North Africa, West Africa, East Africa, Angola and South Eastern Africa. In all these areas the

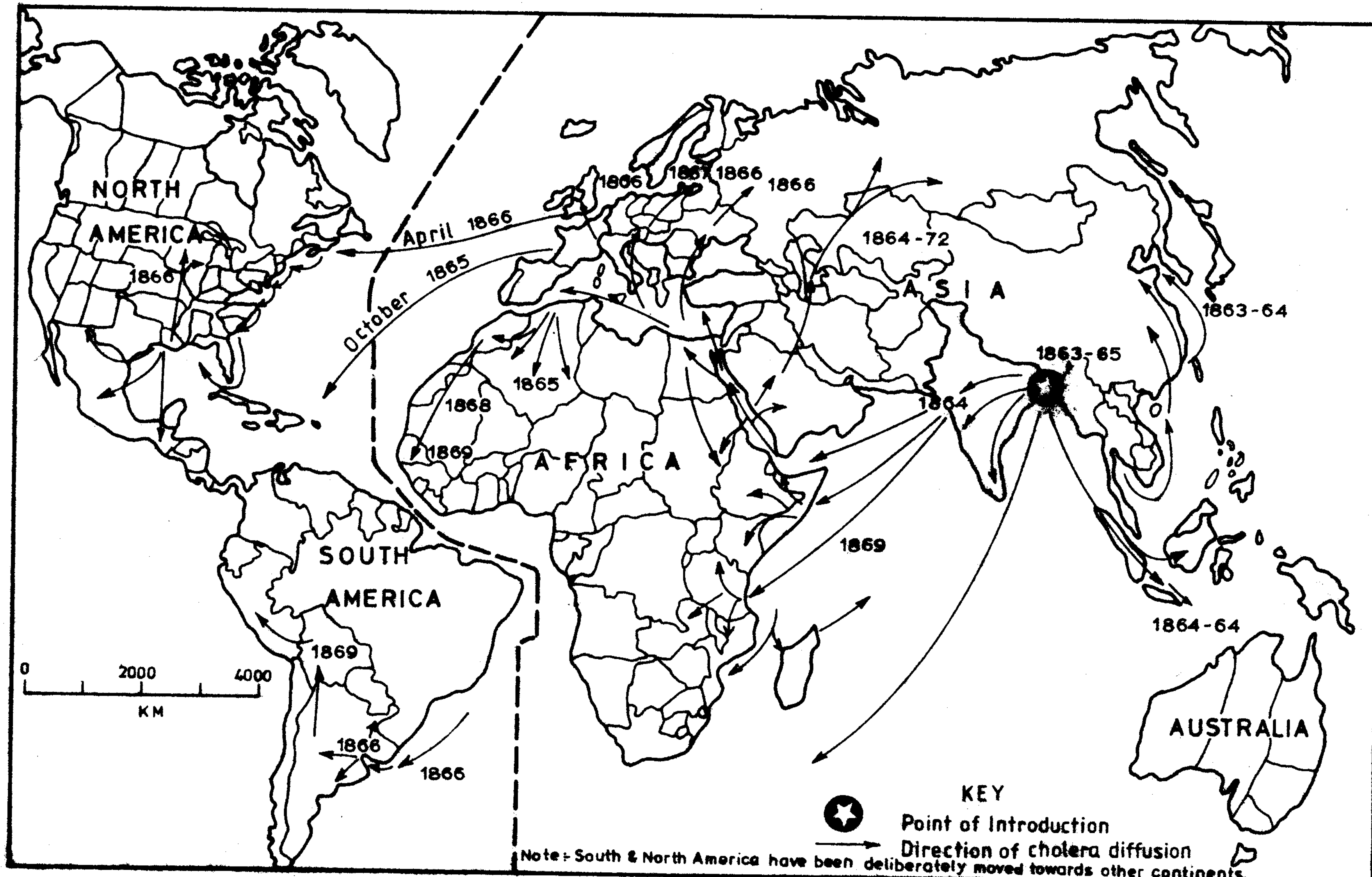


Fig.5.1 WORLD DIFFUSION OF CHOLERA (1863-69) Source: G.F. PYLE (1977) Applied Medical Geography, Winston & Sons, Washingston D.C, page 130

diffusion of cholera has followed different patterns. In West Africa for instance, four diffusion types (coastal, riverine, urban hierarchical and radial-contact diffusion) have been identified and extensively discussed by Stock (1976) and others. In East Africa cholera has been confined to the nomadic peoples of Southern and Eastern Ethiopia, Somalia and Djibouti. In North Africa it has been characterised by sporadic appearance and disappearance. This inevitably poses the difficulty in determining the means of transmission (Stock, 1976:91). The Angolan epidemic has assumed radial contact diffusion in and around Luanda while coastal diffusion along the coast and relocation diffusion along railway lines have been significant as well.

In South-Eastern Africa - particularly in Mozambique and Malawi cholera diffusion has been significant along railway lines, while Zimbabwe seems to have got the infection from Mozambique as a result of liberation troop movements.

The foregoing brief introduction is largely concerned with the diffusion of cholera. In geographic inquiry the concept of diffusion portrays the spreading of a phenomenon, innovation, idea or technique throughout a population or region (Brown and Moore, 1969:121). Consequently diffusion incorporates geographic elements of distance, direction and spatial variation of such a phenomenon as the spread of cholera.

The diffusion theory has been extensively discussed by scholars such as Torsten Hagerstrand, the pioneer of modern diffusion studies, Haggett (1979:297-312); Baker (1977:259); Findlay and Maclennan (1978:310); Abler et al (1977:389-437) and many others. These scholars have basically looked at the diffusion of innovations and information through space and time and their decline (upon reaching saturation level). The diffusion of a disease such as cholera in many respects follows this "innovation" pattern. Discernibly the spread of cholera over time and space, from its endemic "foci" such as Mununga-Nchelenge and Kaputa-Mbala areas, can be explained by various diffusion processes.

5.01. SPATIAL DIFFUSION PROCESSES

Hagerstrand (Haggett, 1979:297:312) and Abler et al (1977:389-439) have recognised four main types of diffusion processes (and combinations of these). These are:-

(a) Expansion Diffusion

In this diffusion process a disease such as cholera like an innovation, spreads from person to person by attacking initially only a few people. These few infected people (now carriers of the disease) transmit the infection to relatives, friends and neighbours - largely through direct contact and other physical means (for instance, by flies). The new victims in their turn pass the infection on to their acquaintances and within a short span of time - depending upon the cholera strain an epidemic soon results. What is implied in this expansion contact diffusion process is that the disease remains in its endemic area but keeps on expanding by wave-like outward movements (Fig 5.2a).

This expansion contact diffusion process was a significant characteristic of Zambia's cholera outbreaks. Upon introduction along the shores of Lake Tanganyika in October, 1978, the cholera infection seems to have consolidated its attacks first among fishermen of Sumbu, Yendwe and Kapembwa before spreading eastwards to other fishing villages surrounding Mpulungu port. From the fishing villages the infection spread south-eastwards into the interior - attaching villages such as Mupata, Musende, Muzabwela, Kasakalabwe and many others. This diffusion was carried out mainly through migrations and expansion contact diffusion (Fig 5.3). Similarly the Luapula Province experienced a cholera epidemic in December 1981. After having been introduced in the villages of Kawama and Lukwesa, the cholera infection first consolidated its attack through expansion contact diffusion before being diffused to areas upstream and downstream.

(b) Relocation Diffusion

This involves the movement of infected people or carriers so that both the people and infection are diffused to a new location through time and space (Abler et al, 1977:390). By a similar process the cholera infection and infected people diffused from the points of introduction in Lake Tanganyika fishing villages of Sumbu to other fishing villages and camps. by boats. Westwards, the infection and infected people diffused to Kaputa by road and again south-eastwards from Mpulungu to Mbala by road.

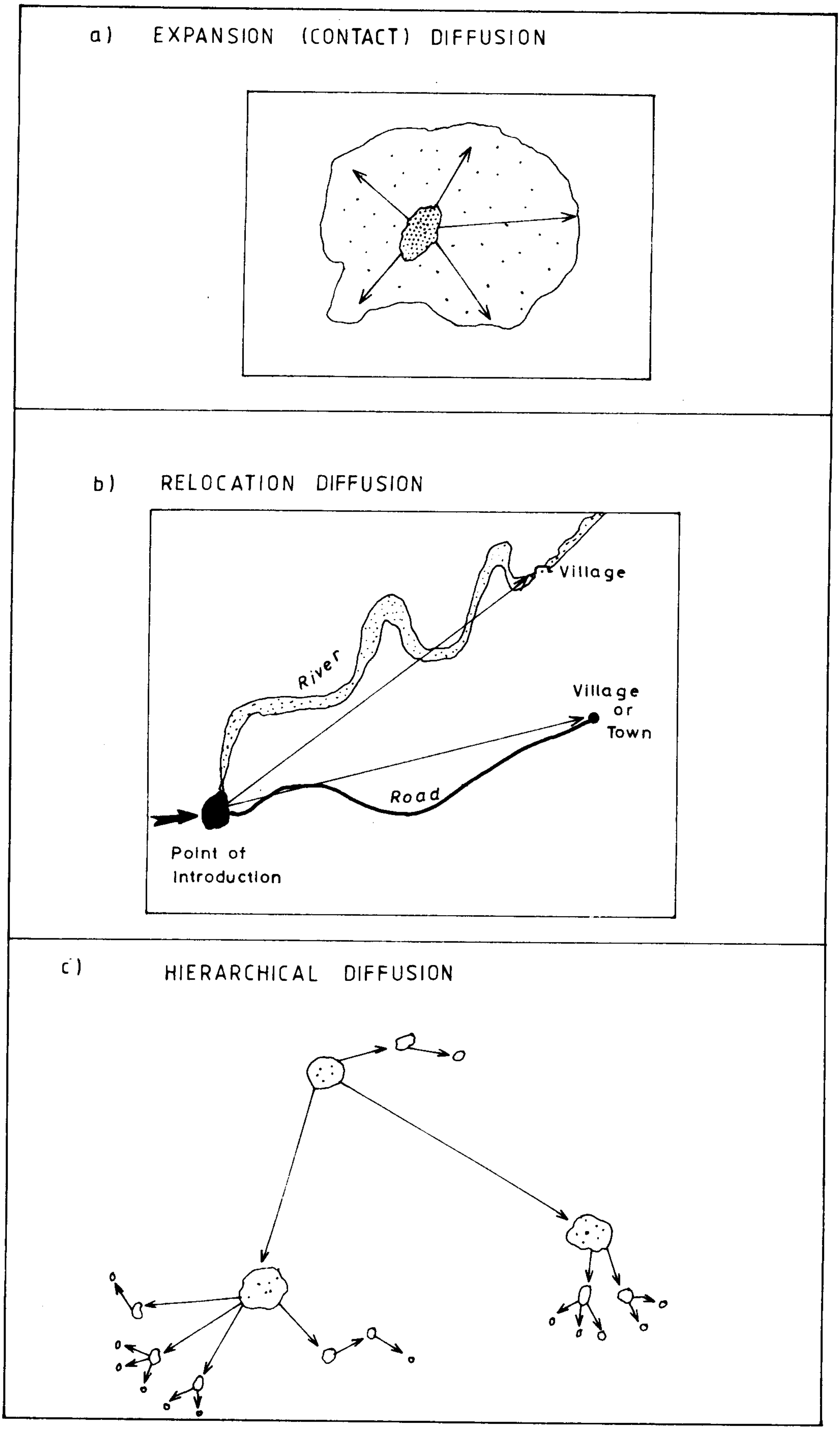


Fig: 5.2. Types of spatial diffusion

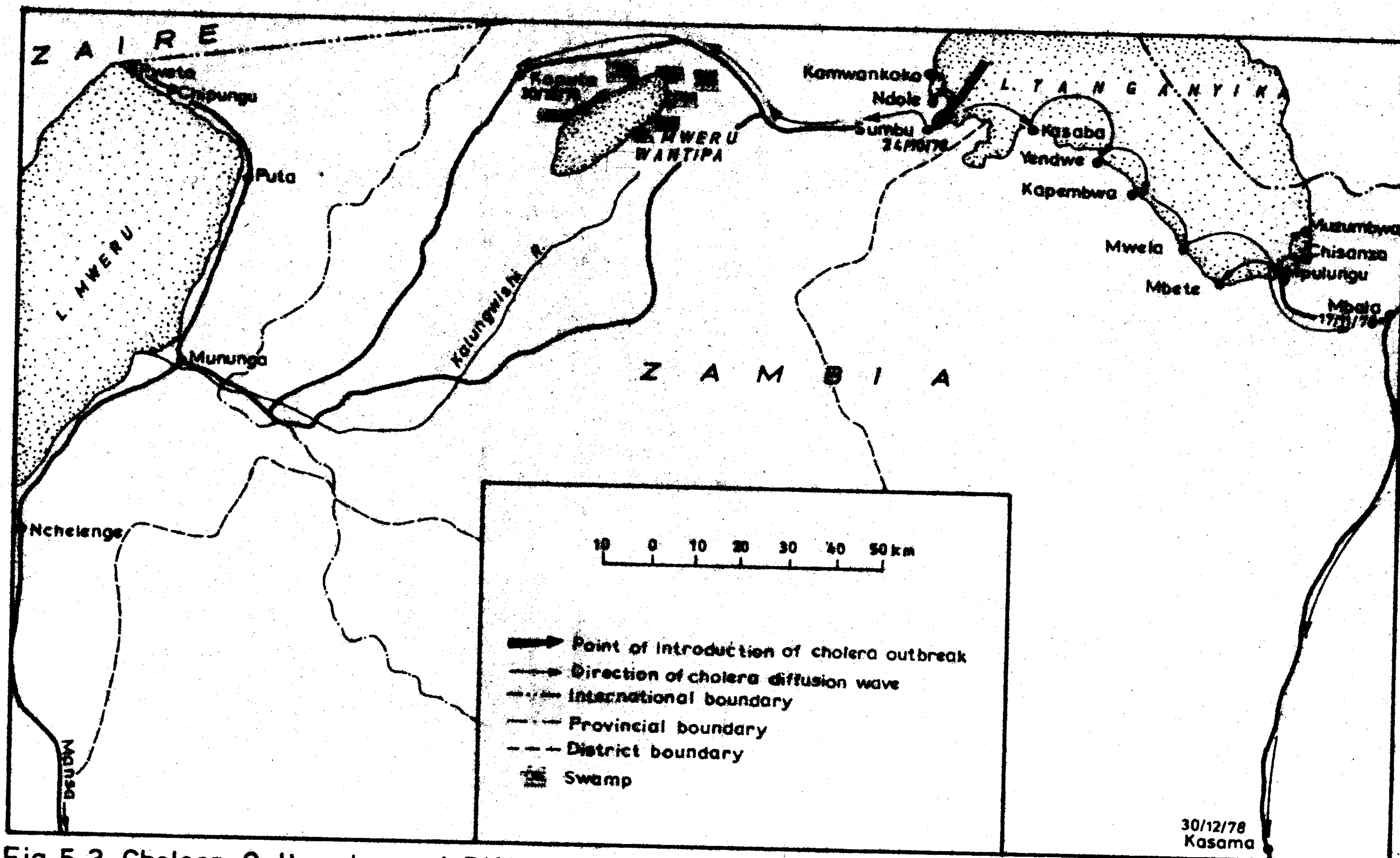


Fig. 5·3 Cholera Outbreaks and Diffusion in Northern Province.

In Luapula Province relocation diffusion of cholera was mainly carried by boats on the river. However motorways along the river valley played a significant role as well (see Fig. 5.2b). Infected people used boats to travel from one docking or fishing village to another. Others used the motorable road transport down the Luapula valley - resulting in cholera diffusion.

(c) Contagious Diffusion Process

This type incorporates aspects of expansion contact diffusion process and is almost similar to relocation diffusion. The only difference is that contagious diffusion is greatly influenced by frictional effects of distance. Thus in the case of cholera, the probability of the disease being rapidly passed from one person to another is greater where there is high population density. Inversely sparsely peopled areas seem to record few cholera cases. This explains the higher cholera cases in high population density areas of the Luapula-Mweru Valley such as Kashikishi, Nchelenge and Mununga. The Mpulungu area on the shores of Lake Tanganyika is another example of high density area with high cholera incidence. Plateau areas such as Kawambwa and parts of the Mbala-Kasama area with relatively sparsely distributed populations reported fewer cholera cases. Generally then the rapidity with which the cholera infection diffused appeared to decrease with increasing distance away from centres of dense population (Fig 5.4). However, geographical distance does not always strongly influence the diffusion processes. It is observed sometimes that due to faster modes of transportation cholera outbreaks might appear to leap-over many intervening places and people. Such faster modes of transport might include aeroplanes for example between Kasaba or Mbala and other distant places (such as Kasama, Ndola and Lusaka) and motorways. During the dry season and the first half of the rainy season, the dirt roads serving Luapula and Northern Provinces are fairly passable. Thus fast motorable transport may be considered as a dominant factor in the rapid diffusion of cholera in the two provinces.

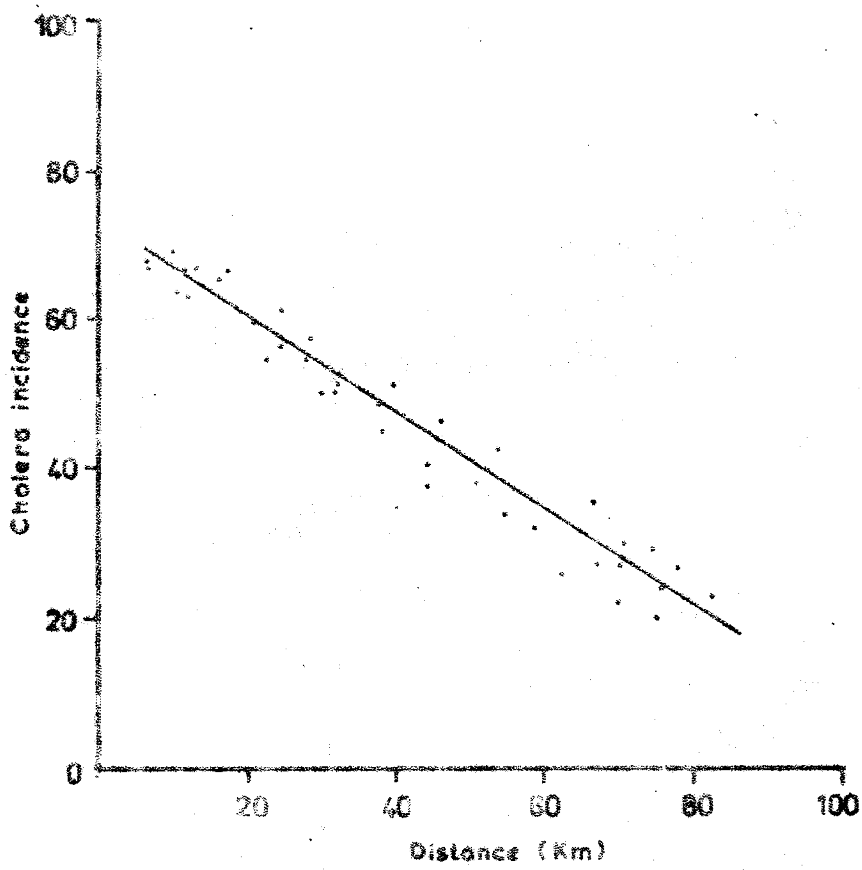


Fig.5.4 The effect of distance upon the incidence of cholera

(d) <u>Hierarchical Diffusion Process</u> (Fig 5.2c)

This process concerns the diffusion of phenomena in relative space in which cities and bigger urban areas may be connected by very strong transmission routes or channels. This type of diffusion is normally characterised by leap-frogging (Abler et al, 1977:392) in which larger places tend to get the innovation or idea first. This is then transmitted to smaller places or villages. In the diffusion of an innovation or idea therefore, there is a tendency for the phenomenon being diffused to affect "larger" and wealthier people before being diffused to the poor people (Abler et al, 1977:392).

However the diffusion of cholera in Northern and Luapula Provinces partially refutes this contention. While it may be true that cholera could attack densely populated areas with amazing rapidity, it is not true that "larger" and wealthier people are affected first. The inverse situation is the truth: cholera attacks first and mostly poor people living in poor sanitary conditions particularly in the rural areas. Thus the hierarchical model seems to be irrelevant as far as cholera diffusion in the study area is concerned. It is however only partially confirmed in places, for instance rural market or commercial centres such as Kashikishi, Nchelenge and Mpulungu with dense population nucleations become fairly susceptible and vulnerable to cholera attacks. As already discussed in chapter four, urban importance of a place seems (though weakly) to affect or induce higher cholera incidence. However larger urban centres such as Kawambwa, Mansa, Mbala and Kasama with better sanitation, appear to be least affected by the cholera outbreaks. In addition these areas also happen to be plateau areas which are less conducive to cholera vibrio survival.

Normally, actual diffusion processes do not however, always fit neatly into any one category (Abler et al, 1977:393). In expansion contact diffusion for instance, a disease such as cholera might spread steadily outward from its endemic focus by the contagion process. This process might also involve some degree of movement and thus relocation of both people and phenomenon. Accordingly, most of the diffusion patterns are combinations of different basic processes. Besides, localised diffusion processes such as riverine, lakeshore, and radial contact diffusion played a very significant role in the dissemination of cholera in Northern and Luapula Provinces.

(i) RIVERINE DIFFUSION

Riverine diffusion process is fittingly applicable to Luapula Province - the only affected province with a sizeable river - the Luapula River (Fig 5.5). It is believed that cholera broke out in Kasenga district of Zaire during the first week of December 1981. It was introduced into Zambia at various docking and fishing villages by travellers, fishermen and refugees suffering with cholera from Kasenga. From the points of introduction the cholera infection diffused upstream and downstream mainly by fishermen - a number of whom had caught the infection. These fishermen used to defecate in the river water.

The river water is the main source of drinking water for most villages along the river. In addition to fishermen contaminating the water, river passenger transport by boats or

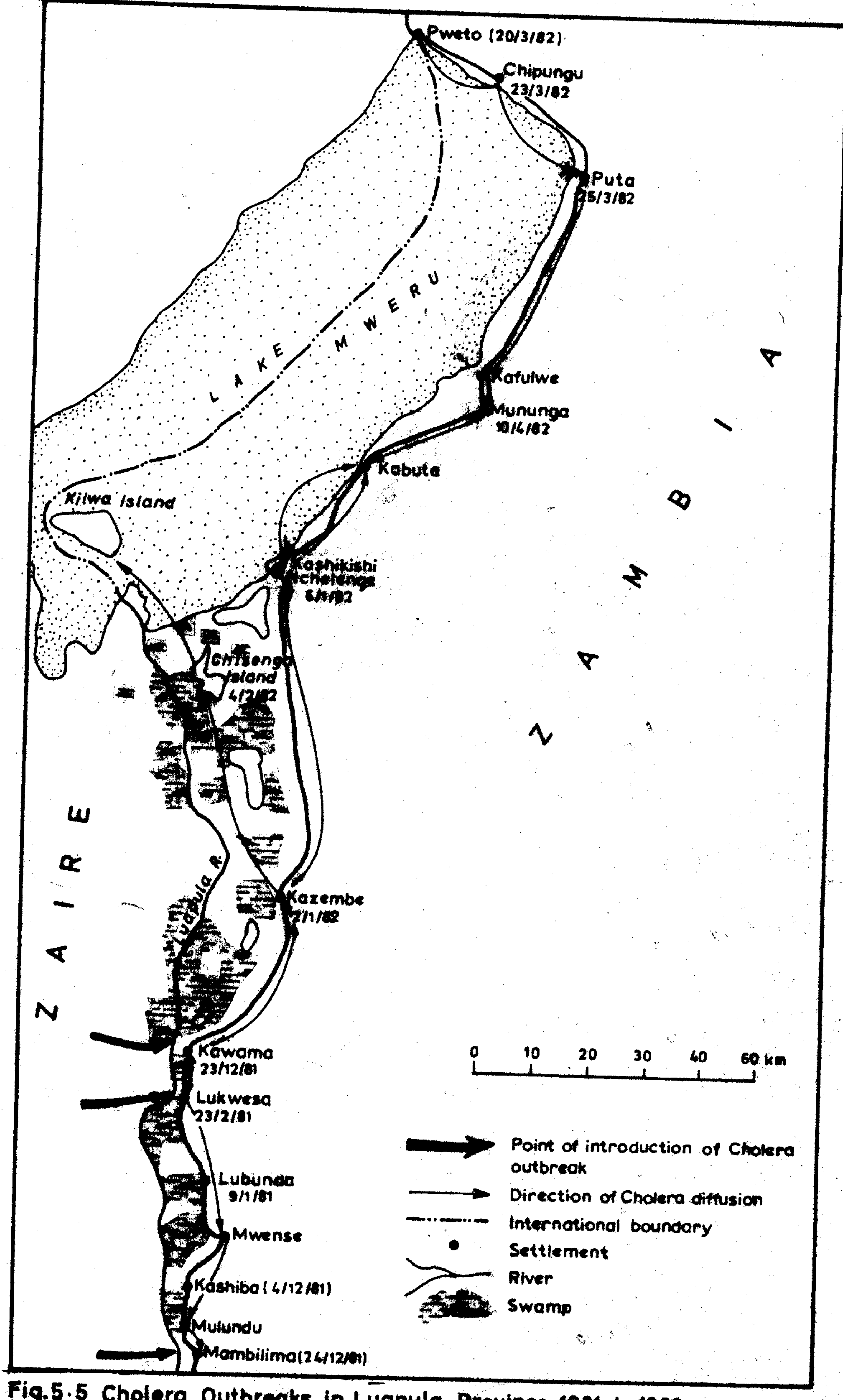


Fig.5.5 Cholera Outbreaks in Luapula Province, 1981 to 1982

"ifyombo" is another source of transmitting cholera vibrios. On these boats Zambian and infected Zairean passengers intermingled and through such contact, the cholera infection diffused rapidly. Besides person to person diffusion, a great deal of the outbreaks were due to direct water contamination as the lavatories on the boats opened directly into the river water.

Thus the cholera infection diffused down to the lake Mweru area where the islands of Kilwa and Chisenga provided a high degree of intermingling between Zaireans and Zambians through mutual fishing and trade businesses. (See also Figs 5.5a(i) and (ii) and 5.6b(i) and (ii)).

(ii) LAKESHORE DIFFUSION

While the riverine diffusion model is largely confined to Luapula Province only, the lakeshore diffusion model is applicable to both provinces. In this case cholera might have been introduced at one fishing camp or village whence it may have spread to other fishing villages by fishermen before being diffused into the interior. The Pweto cholera outbreak in March 1982 (Fig 5.5) might have spread along the lake rather than by road precisely because between February and April the dirt road along the Lake Mweru area is almost impassable. Similarly from Kashikishi cholera might have diffused northwards and southwards along the lakeshore by boats and canoes. In Northern Province, from the introduction point of Sumbu, the infection diffused northwards along the coast to Ndole and Kamwankoko fishing villages, and then south-eastwards to Kasaba,

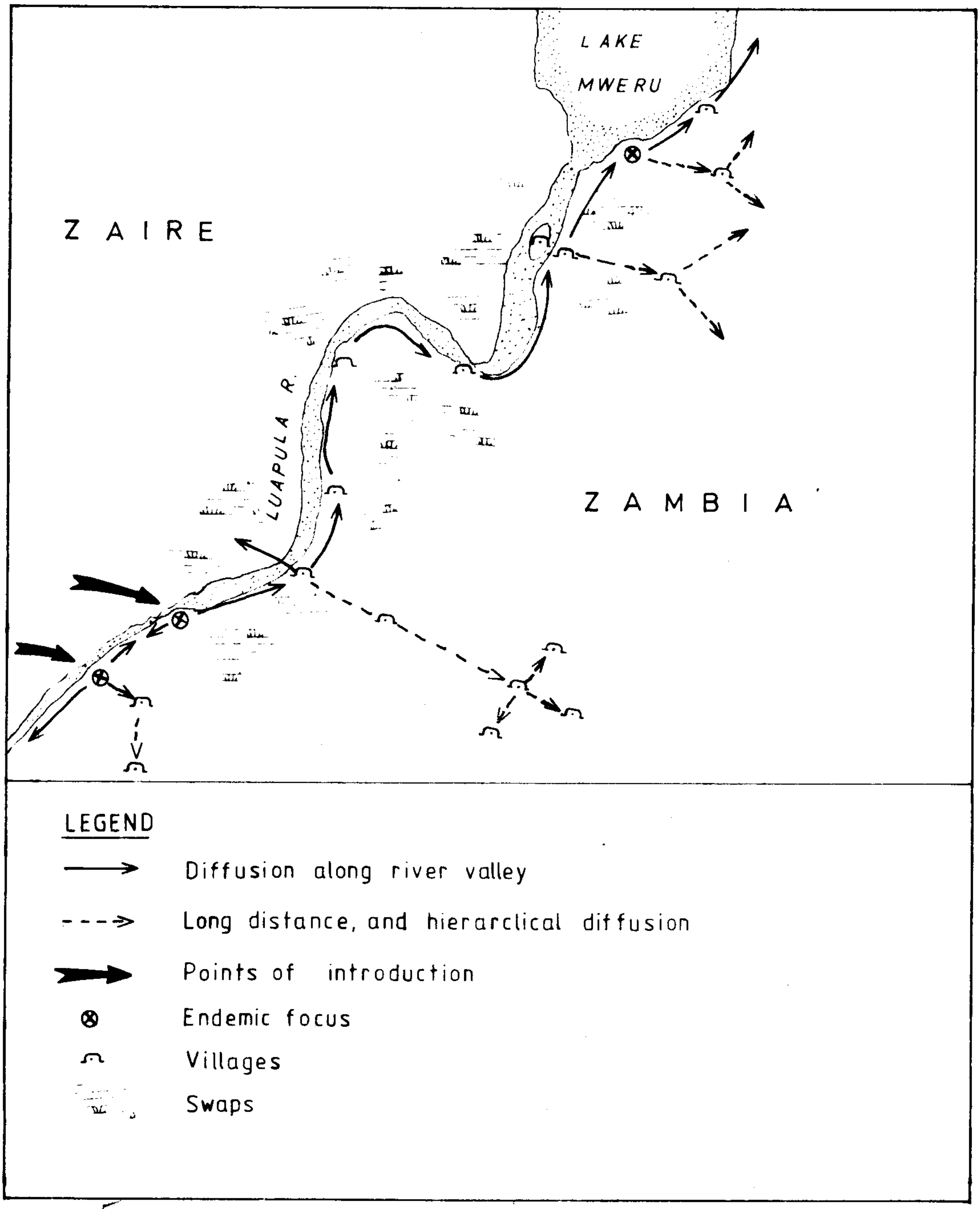
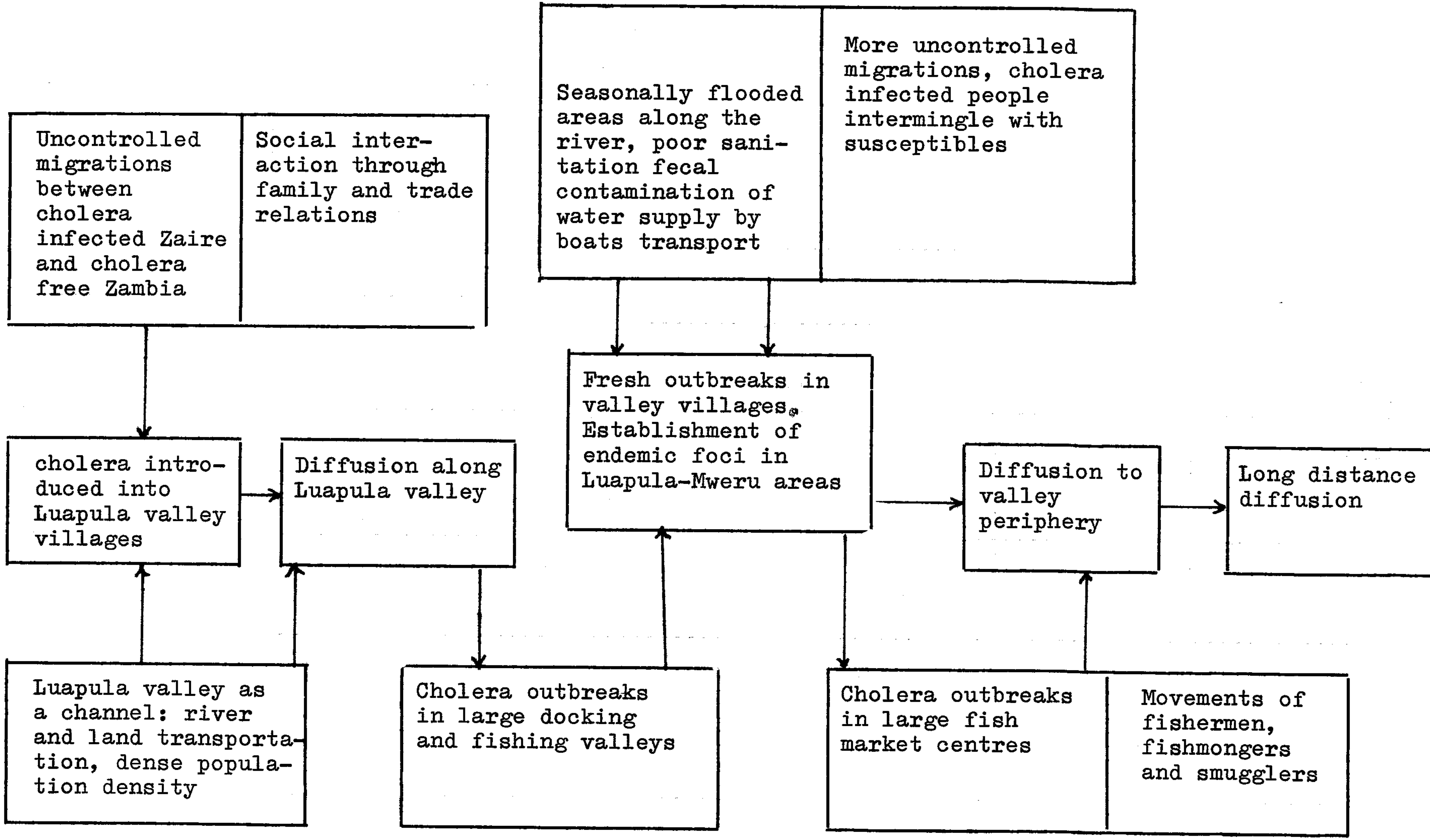


Fig. 5.5a(i) Schematic Map of Riverine diffusion

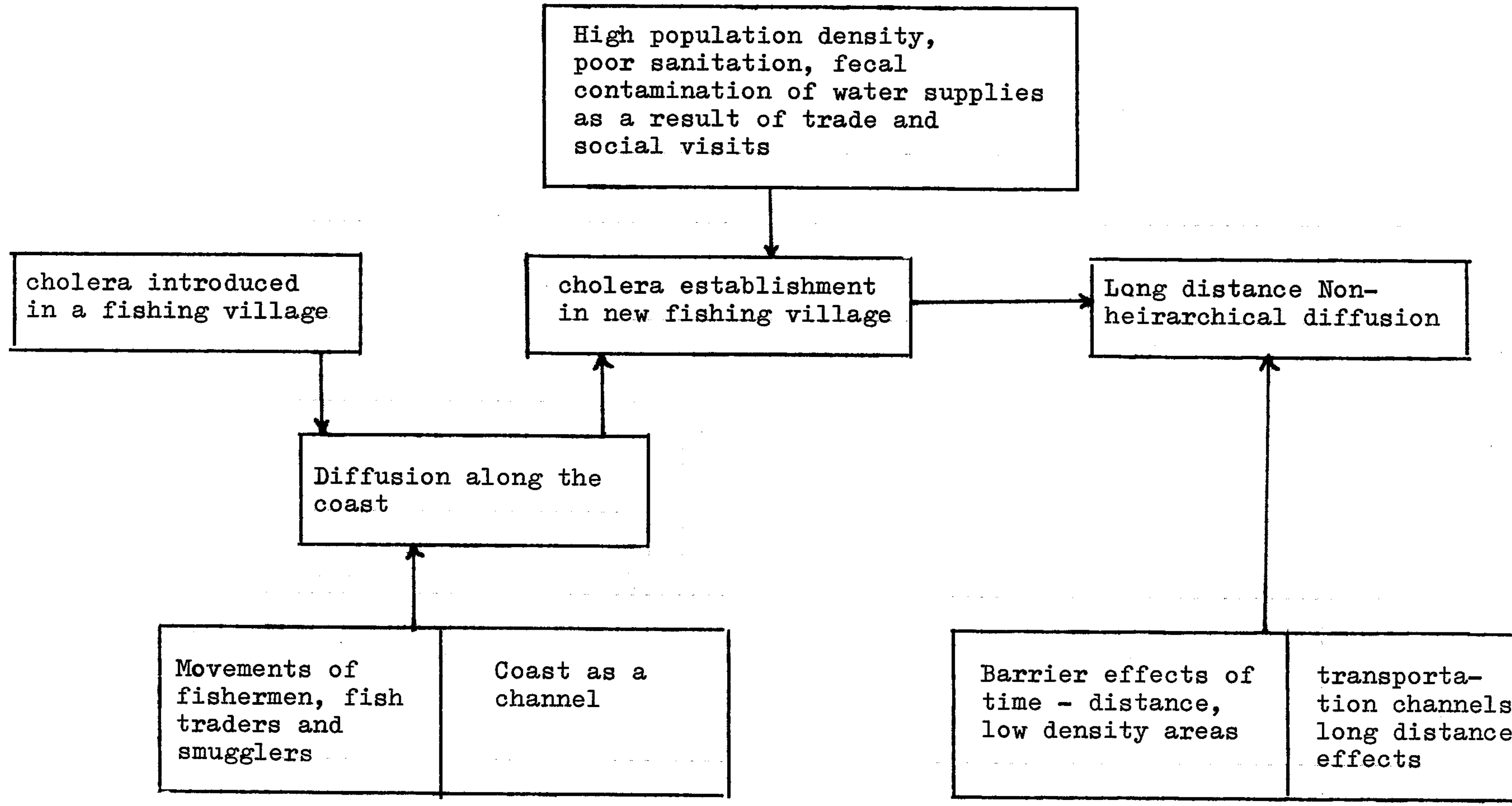
Prepared by the author based on R. F. Stock, Cholera in Africa London: International African Institute 1976 P. 53

5.3a(ii) RIVERINE DIFFUSION MODEL



Prepared by the author based on
R.F. Stock, Cholera in Africa, 1976 p.53

5.6b(i) <u>LAKESHORE DIFFUSION MODEL</u>



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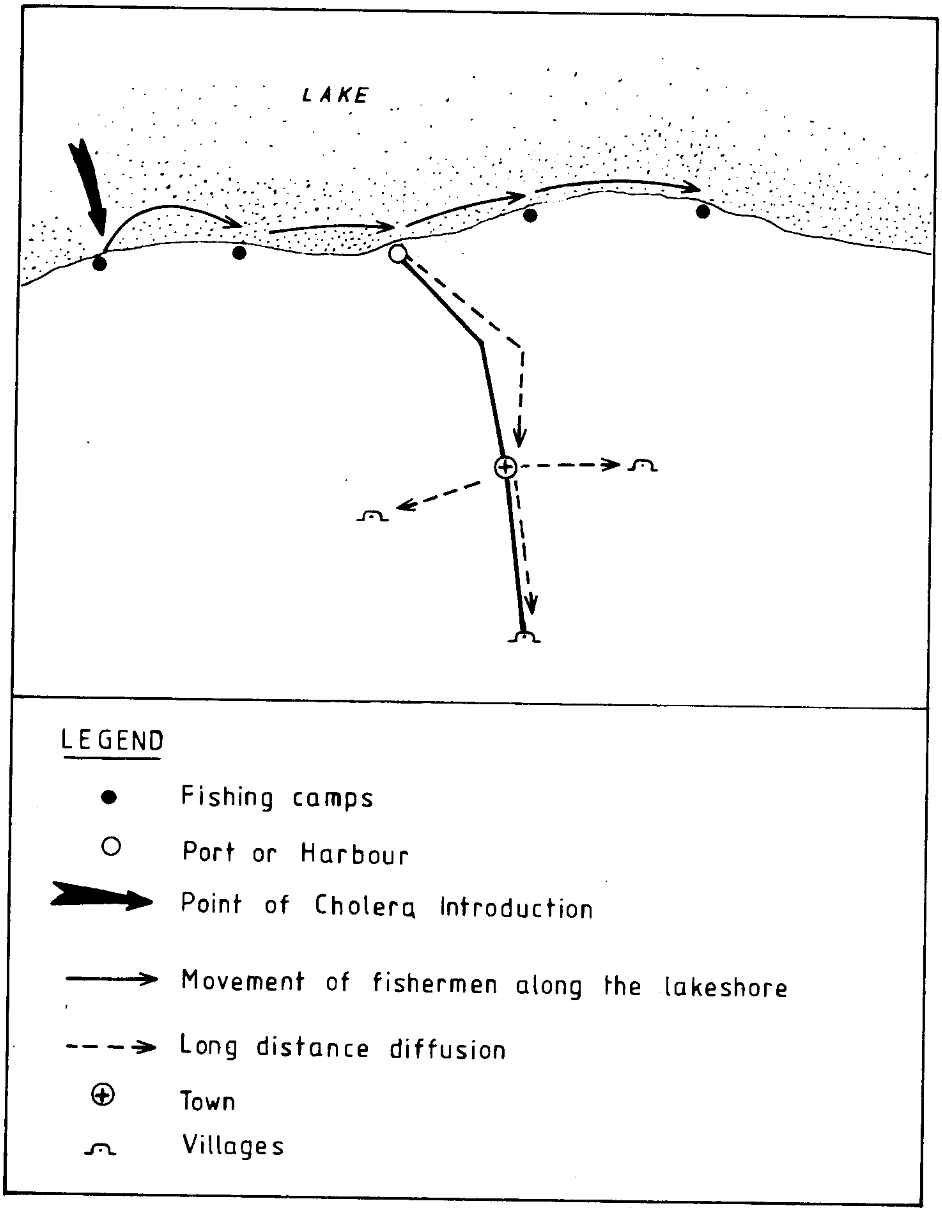

Fig: 5.6 b (ii) Schematic Map of Lakeshore Diffusion

Prepared by the author based on R.F Stock, Cholera in Africa 1976 p 42

Kapembwa, Mwela, Mbete up to Mpulungu (Fig 5.3). Larger fishing villages such as Sumbu and Mpulungu were attacked first because of their attractive factor (market centre for instance). Later, cholera diffused by land routes (paths and roads) into the interior. Here a slight hierarchical diffusion model is applicable to some extent, because a larger place such as Mpulungu was attacked first before such smaller places as Chisanza and Muzumbwa (north of Mpulungu) received the infection from Mpulungu. Similarly Sumbu which is larger, received the infection before passing it on to Ndole and Kamwankoko (in the north) and Kasaba, Mwela and others in the south-east. But this hierarchical diffusion is insignificant.

(iii) RADIAL CONTACT DIFFUSION

According to R.F. Stock (1976:61), the term radial contact diffusion is used to identify unchannelled wave-like contact diffusion from a central focus. In Zambia the best example of this type is perhaps the introduction of the cholera infection at lakeshore areas of Mpulungu and Nchelenge-Kashikishi.

The lake Tanganyika cholera outbreak was introduced at Mpulungu from Sumbu during mid-November, 1978. From here the infection spread quickly to neighbouring villages of Musende, Muzabwela and Mupata. By relocation, another outflow of the infection was channelled through the road to Mbala - resulting in over 350 clinically proved cholera cases in the whole district. Stringent quarantine measures (including travel prohibition and mass vaccination programmes) hindered the spread of the disease to other districts such as Kasama (south of Mbala) and Isoka in the south east. Moreover there was less attraction in terms of migration from Mbala to Isoka which is a smaller place. Hence fewer, if any migratory people carrying the cholera infection ever travelled to Isoka.

Generally, given suitable environmental conditions, a cholera outbreak, like most other outbreaks, forms a transmission cycle of man-environment-disease. Thus under such ideal conditions, the disease continues to spread until the equilibrium so established is disturbed through change of the "favourable" environmental conditions (Stock, 1976:84). Such an equilibrium could also be disturbed through the decline of a susceptible population (Fig 5.7). In addition, the infection declines when the prevailing conditions are no longer conducive to disease occurrence and its diffusion.

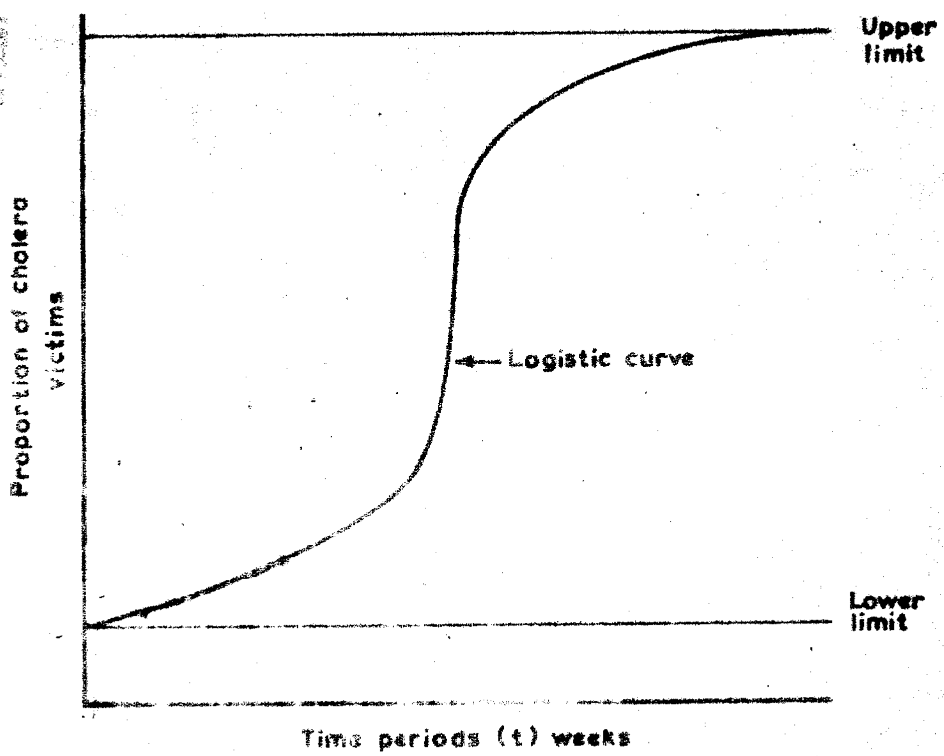

Fig. 5.7 Logistic curve.

This is normally a consequence of various barriers.

5.02 BARRIERS

The process of the diffusion of cholera does not occur on smooth and homogeneous surfaces. Many objects normally get in the way, slow down the diffusion or change the course of the diffusion process. Thus the disease is channelled more quickly in some directions (for instance along river valleys, lakeshore areas and roads) than in others.

Generally barriers in the way of a diffusion wave can have three basic effects:-

(a) Upon reaching an absorbing barrier, a disease infection wave may be stopped completely. Near such a barrier all the energy is completely absorbed so that the diffusion process is halted. Examples of this type of barrier in the study area include impenetrable swamps such as those around Lake Mweru Wantipa and Lake Bangweulu. Other absorbing barriers might be high steep mountains such as the steep escarpment facing the Mpulungu area. In both cases the diffusion of the cholera infection has been stopped because much of the terrain is either uninhabited or fewer people have settled here.

(b) Upon reaching reflecting barriers, a disease diffusion wave may be bounced off as was the case when the cholera diffusion wave in Luapula Province failed to go beyond Mambilima Falls. This was perhaps because of lack of dense population around the gorge and lack of navigation (river transportation) beyond the falls. The cholera diffusion wave was channelled back into the valley below the falls.

(c) Upon reaching a permeable barrier, cholera diffusion may not be stopped completely. For instance narrow river or lakeshore strips do not entirely stop communication between people living on opposite sides. The result is that the cholera infection is transmitted across although the transmission rate is reduced considerably. It is much less on the recipient side until it becomes endemic. This is evident in the Luapula outbreak. Kawama and Lukwesa villages were safe from cholera until cholera refugees from neighbouring Kasenga in Zaire just across the river began flooding in. Soon Kawama and Lukwesa became endemic areas.

Besides the effects of barriers upon disease diffusion the survival and containment of the cholera infection depends largely upon the characteristics of the cholera vibrios. These include the hardiness of the strain - either vibrio cholera or El Tor - with El Tor being the more aggressive. Other factors might be the form of introduction and suitability of the environmental conditions. That is the involvement of inter-relationships, for instance: poor sanitation; overcrowding; inadequate sewage (excreta) and refuse disposal methods; unprotected and often contaminated domestic water supplies. Such conditions and those discussed at length in chapter four are to be found in rural marketing centres of Kashikishi, Mununga, Nchelenge, Lukwesa and Mpulungu.

CHAPTER SIX

6.00 CONCLUSIONS AND SUGGESTIONS

The present study is aimed at utilizing geographical skills and methods in identifying and analysing spatial relationships between cholera occurrences and certain environmental factors. The investigation is confined to Northern and Luapula Provinces since these areas had the highest reporting cholera cases.

Generally the following relationship have been discussed:

(a) There is a significantly strong association between poor sanitation (that is, inadequate excreta and refuse (garbage) disposal methods, coupled with unprotected, polluted water supplies), and high incidence of cholera. To this effect the analyses have revealed a high percentage (28.6 per cent) of cholera victims who defecate in the bush or water - especially in fishing communities thereby contaminating the environment. In addition, the local dissemination of the cholera infection has been a function of local conditions such as overcrowding with poor sanitation resulting in feacal contamination of domestic water supplies. Furthermore it is evident that nearly filled-up latrines together with refuse dumps near the houses seemed to have significantly facilitated the outbreaks of cholera in poor rural communities in the two provinces. The untreated piped water supplies in some areas such as Nchelenge and Kashikishi also helped spread cholera. Furthermore, the chances of person to person transmission of cholera are greatest where there is close physical contact between a vibrio carrier and susceptibles. For example festivals such as Chief Kazembe's Mutomboko ceremonies, funerals, home-caring of cholera victims, and intermingling at market places, all have enhanced the transmission of cholera in Northern and Luapula Provinces.

(b) There is a slight but positive relation between river and/or lake environment and higher cholera incidence. To test this relationship, the Student's t test and phi - coefficient tests were applied. The analyses revealed that the riverine/lake environment was very significant in the outbreaks and diffusion of cholera in the study area. This was particularly true along the Luapula river and along the shores of Mweru, Mweru Wantipa and Tanganyika lakes. While the brackish waters of the swampy lagoons along the river and lakes provided the necessary breeding and "nesting" grounds for the cholera vibrios, the waterways provided easier and faster transmission channels for the infection among docking and fishing villages. Thus, socio-economic factors, aside, hydrological and environmental conditions played a significant role in the spread and distribution of cholera in the study area. Accordingly, plateau areas such as Kawambwa-Kasama areas and the Mbala highlands - generally poor in water supply were essentially less affected by cholera.

(c) There is a slightly weak relationship between high population density and rapid diffusion of cholera. Inspite of the dense populations along the Luapula valley and in the Mpulungu area the reported scattered cholera cases could not confirm strongly the significance of high population density on the outbreaks of cholera. This resulted in a weak relationship between the two variables. Ideally dense populations and cholera incidence show a direct positive relationship (Fig 6.0).

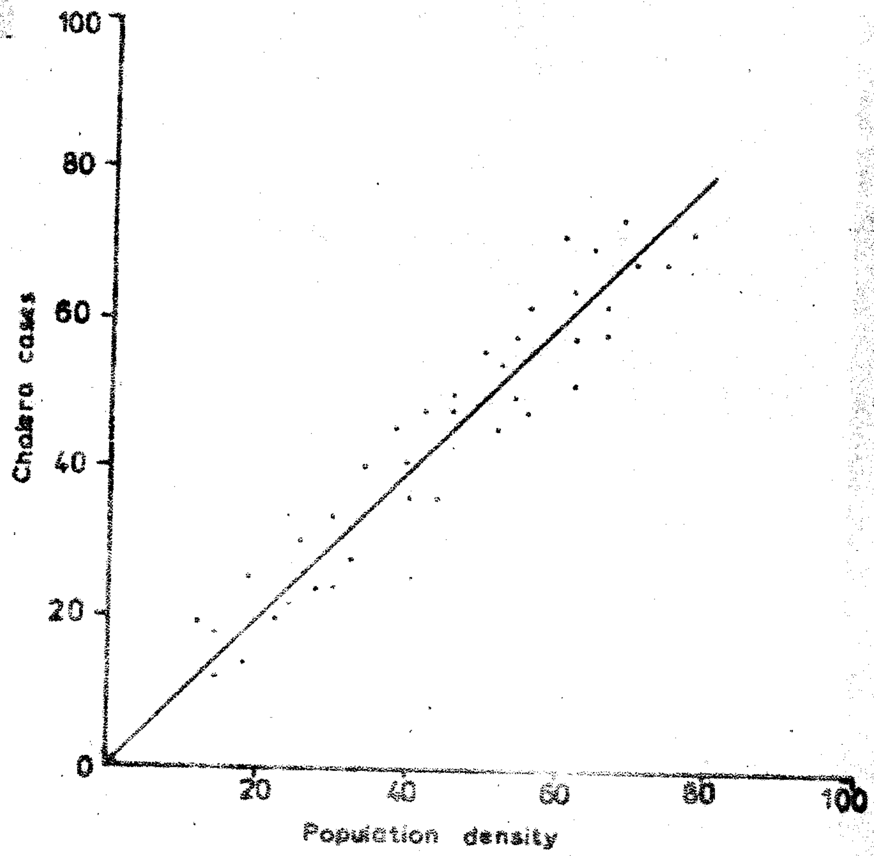

Fig.6.0 The relationship between population and incidence of cholera.

But in the Zambian context as is indeed the case in most developing countries, sporadic reporting, underreporting and non-reporting are common features which often lead to negative or weak positive relationships between, for instance, population density and the outbreaks and diffusion of cholera.

(d) There is a slight but weak relationship between high urban importance and high cholera incidence. This again could be due to non-reporting of cholera cases in rural marketing centres. These centres normally tend to attract large numbers of people including cholera-infected ones. Ideally therefore, high cholera incidence should have been significantly influenced by high urban importance.

A knowledge of the above mentioned social and physical conditions leads to the prediction of cholera outbreaks and diffusion. For instance, radial contact diffusion is most likely to attack overcrowded rural and urban areas while long distance diffusion is most likely to affect any parts of Zambia connected by air to the locally endemic areas (Nchelenge or Mbala-Kaputa areas). In addition fast modes of transportation within Zambia would facilitate inter-regional diffusion of cholera.

Apart from rural and fishing communities being mostly affected by cholera, recently built unplanned squatter compounds surrounding such big towns as Kasama, Mansa, Mbala with poor sewage and garbage disposal methods and unprotected water supplies often became easy targets for cholera attacks. Furthermore, the identification of location and impact of certain channels, barriers, and local endemic foci, is essential in predicting cholera diffusion patterns.

6.01 CONCLUSIONS

Besides the afore-mentioned relationships and associations between cholera outbreaks and certain environmental factors, the study has drawn out the following conclusions:-

(a) It is interesting to note that Zambia's neighbours: Angola, Zaire, Tanzania, Malawi, Mozambique and Zimbabwe had some of their parts heavily affected by cholera between 1973 and 1975.
Zambia remained entirely unscathed until October 1978. This could mean one thing among many; that there was either no reporting of cholera outbreaks in the country, or that Zambia was simply not affected by cholera.

(b) The 2047 cholera cases and more than 200 deaths due to cholera could, in actual sense, be much higher. But such aspects of underreporting, non-reporting and inaccessibility of the affected areas (swamps and islands) could not entirely be ruled out.

(c) The cholera outbreaks seemed to have been significantly influenced by the onset of the hot season from October to December. The hot humid and wet conditions during the period from December to March, in their turn accelerated the cholera infection.

(d) The relatively stagnating and sluggishly flowing brackish waters in parts of the Luapula river and lakes Mweru and Mweru Wantipa provided the necessary breeding and "nesting" grounds for cholera vibrios.

(e) Unchecked population mobility between cholera affected areas (reservoirs) in Zaire and Tanzania on the one hand, and Zambia on the other, facilitated cholera transmission.

(f) Interrelationships of poor sanitation, overcrowding inadequate sewage and refuse disposal methods, unprotected and contaminated domestic water supplies, all significantly accelerated the outbreaks and diffusion of cholera in the two provinces.

(g) While riverine diffusion process (applicable along the Luapula river) and lakeshore diffusion process (along lakes Mweru and Tanganyika) were instrumental and very significant in the diffusion of the disease, urban hierarchical diffusion pattern in Zambia's cholera outbreaks was almost absent.

6.02 <u>Implications and Suggestions for Zambia</u>

(a) Given all the necessary cholera conditions (such as proximity to the infection's source area, dense populations, high urban importance index and poor sanitation) the riverine diffusion model, could easily be applied to the flood plains of Western Province and the Middle Kafue river between, Lukanga and Kafue Gorge.

(b) The lakeshore diffusion model could be applied to areas with water environment with brackish stagnating water such as parts of the Bangweulu and Lukanga swamps.

(c) Since disease epidemics such as the cholera epidemics recognise no political boundaries, it is imperative that control measures should be undertaken in order to make the environment less conducive for the survival of cholera. To this end, intergovernmental cooperation and consultations on measures of effective disease control should be sought. One of the main problems that the health authorities in Zambia encountered during the control of cholera epidemics, was lack of cooperation from neighbouring countries in controlling the movements of people.

(d) Within the country quarantine measures and other preventive procedures should be undertaken seriously. To lift quarantine measures for fear of violating basic human freedoms during disease outbreaks, is to help accelerate the occurrence and spread of the disease. Other serious control measures should include construction of pit latrines, say every two years, adequate chlorination of water supplies regularly, conducting environmental clean-up campaigns at section and ward, or village levels, mass vaccination programmes (even though it is now claimed that these are not effective) and cholera surveillance programmes must be formed at village levels.

(e) Most rural health institutions are critically understaffed. There must be a vigorous and deliberate government policy to induce and attract medical personnel to rural areas. For instance, the government could introduce rural allowances, create promotional avenues and offer better social facilities than are currently being given.

(f) In almost all cases except for big hospitals at Mansa, Mbereshi, Kashikishi, Kasama and Mbala, rural health institutions have no motorable transport. The only vehicle - boat or bicycle they had was broken down. In such circumstances inter-departmental cooperation should become imperative.

(g) Departments of local government, water affairs, education, police, public works and all others should work hand in hand with that of health in order to provide safe drinking water, hygienic sanitary services, and basic hygiene education.

In this respect, they should all work together in ensuring that street vendors do not sell food and local brews in open unhygenic places as is the case in most of the study area.

(h) There should be a definite policy by the Ministry of Health to ensure, efficient and accurate reporting of disease outbreaks.

Generally, then, effective control of cholera epidemics requires a knowledge of the spatial diffusion processes in order to contain the spread of the infection. For instance radial diffusion might be controlled by concentric vaccination methods around the foci of the infection. Long distance diffusion might be contained by effective quarantine and inoculation procedures.

Finally, whatever the deficiencies there might be, the present study highlights that infections diseases - cholera included - are a major health problem in Zambia. Such problems require, inevitably, geographical analyses and explanations for greater understanding. It is hoped that this study in the context of the Medical Geography of Zambia will provide the basis for further detailed geo-medical researches.

APPENDIX I

THIS QUESTIONNAIRE IS STRICTLY CONFIDENTIAL AND ALL INFORMATION RESULTING FROM THIS WILL BE UTILIZED FOR RESEARCH PURPOSES ONLY

Department of Geography
UNZA
P.O. Box 32379
LUSAKA

SOCIO-ECONOMIC ASPECTS OF CHOLERA VICTIMS AND NON-VICTIMS

RESPONDENT'S

SERIAL NUMBER ________________ DATE ______________

NAME: ______________________ ADDRESS/VILLAGE: _______

Location of village ________________________________

Religious Denomination ______________________________

Occupation: (a) During rainy season ___________________

(b) During dry season ____________________

Kindly answer the following questions as honestly and accurately as you can.

01. What is your marital status?

1. Single
2. Married
3. Divorced
4. Separated
5. Widowed

02. Sex

1. Male
2. Female

03. Occupational structure:

1. Farming
2. Self-employed
3. Professional (Teacher/Forestry/Agricultural/Health)
4. Manufacturing
5. Semiskilled labourer
6. Unskilled labourer
7. Informal sector
8. Others ____________________

04. Level of income:

1. Lower (less) than K50.00 per month
2. Middle K50.00 - K200.00
3. Higher (more) than K200.00

05. Educational attainment:

1. Pre-School
2. Grade 1-7
3. Form 1-2
4. Form 3-5
5.. University/College

06. Household (family size):

1. Small (less than 3)
2. Medium (3-5)
3. Large (6-11)
4. Extra large (12 or more)

07. Size of house:

1. Small (1 living room and 1 bedroom)
2. Medium (1 living room and 2 bedrooms)
3. Large (1 living room and more than 3 bedrooms)

08. (i) House type:

1. Wooden
2. Brick
3. Wood and mud

(ii) Roof type:

1. Thatch
2. Corrugated sheets

09. Floor area of house:

1. Small (with less than 150sq. m. of space)
2. Medium (150-300sq. m. of space)
3. Large (above 300sq. m. of space)

10. How long have you been living in this area?

1. Less than 5 years
2. Between 5 and 10 years
3. Between 10 and 20 years
4. More than 20 years

11. Have you ever been away from this area on a visit within the last 5 years.

1. Yes
2. No

12. If your answer to question 7 is <u>YES</u>, where did you go to visit and for how long?

(a) ____________________ (b) _______________days/weeks/months/year

13. Was the visit

1. a social visit
2. a service visit
3. a shopping visit
4. for some gathering (meeting)

14. When did you first contract cholera?

1. in 1978
2. in 1979
3. in 1980
4. in 1981
5. in 1982

15. Do you think your visit might have something to do with contracting cholera?

1. Yes
2. No

16. Did you or your family receive any visitor(s) just before you contracted the disease?

1. Yes
2. No

17. Where did the visitor(s) come from? ____________________

18. Where do you think the disease came from into your village (area)?

____

19. Apart from you how many other members of your family suffered from cholera?

____

20. Diet (Daily consumption):

Food	FREQUENT (Times a week)	OFTEN (Times a week)	RARE (Times a week)
	(5 - 6)	(3 - 5)	(0 - 2)
Meat			
Milk			
Fruits			
Eggs			
Fish			
Vegetables			

21. Are there food sellers in your area?

1. Yes
2. No

22. What types of food do they sell?

1. Fish
2. Crops
3. Brews (sweet beer)
4. Locally brewed beer
5. All these

23. Nearest Hospital/Clinic/Health Centre:

1. 1-5 km
2. 5-10 km
3. 10-20 km
4. More than 20 km

B. <u>ENVIRONMENTAL SANITATION</u>

24. Garbage collection/Disposal of sewage

1. in open pits
2. thrown away near the house
3. Municipality collection
4. in the river/lake

25. Type of toilet:

    1. Pit latrine
    2. Flashing toilet
    3. Use of bush around
    4. Use of the water around

26. How old is pit latrine?

    1. 1 - 2 years
    2. 2 - 4 years
    3. More than 4 years

27. Does water stagnate near the house during the rainy season?

    1. Yes
    2. No

28. Is the village flooded during rainy season?

    1. Partially
    2. Wholly
    3. Does not

29. Source of Drinking water

    1. River/Stream
    2. Lake
    3. Bore hole
    4. Tap water
    5. Well.(dug out)
    6. Ditch

30. Distance travelled to fetch drinking water

    1. Within 100 metres
    2. 100 - 500 metres
    3. 500 - 1000 metres
    4. More than 1 km.

31. Water contamination

    1. possible from sewage/garbage disposal
    2. possible from seepage from toilet
    3. possible from disposal of excreta in the water
    4. NIL.

APPENDIX II

QUESTIONNAIRE NO. 2

THIS QUESTIONNAIRE IS STRICTLY CONFIDENTIAL AND THE INFORMATION RESULTING FROM IT WILL BE UTILIZED FOR RESEARCH PURPOSES ONLY

Geography Department
UNZA
P O Box 32379
LUSAKA

MEDICAL (HEALTH) OFFICERS

Kindly answer the following questions as honestly and accurately as you can.

01. NAME: ....

02. SEX 1. Male
2. Female

03. ADDRESS (NAME OF HOSPITAL/HEALTH CENTRE) ....

04. DESIGNATION (JOB TITLE) ....

05.. The recent outbreak of cholera in Zambia was first reported in October 1978, when was your area (site) first attacked by cholera?

Area...................... Date of cholera occurrence

....

06. Where do you think the disease spread (came) from?

....

07. What do you think is the cause of the disease

1. Contaminated drinking water
2. Poor sanitation
3. Uncontrolled immigrations of infected people into unaffected areas
4. Any other reasons ....

08. How many cases did you have in your area? .... cases

09. How many deaths resulted from cholera in your area ......

• Death due to cholera | Date of occurrence

(i) ________ ________

(ii) ________ ________

(iii) ________ ________

(iv) ________ ________

(v) ________ ________

(vi) ________ ________

(vii) ________ ________

10. Has there been another outbreak of cholera apart from the one mentioned above?

1. Yes
2. No

11. If yes, how many other outbreaks of cholera has your area experienced?

Cholera outbreak | Date of incidence

(i) ________ ________

(ii) ________ ________

(iii) ________ ________

12. Areas (sites) affected:

Sites (villages) | Date of incidence

(i) ________ ________

(ii) ________ ________

(iii) ________ ________

(iv) ________ ________

(v) ________ ________

(vi) ________ ________

13. What action has the government through the cholera control Programme, taken in order to reduce the spread of cholera in your area?

1. Application of quarantine techniques
2. Supply of antibiotics and other types of medicine
3. Improvement of water supply
4. Nothing at all

14. Would you like the government to do more than what they are doing at the moment?

    1. Yes
    2. No

15. If yes, please suggest what you would like the government to do in order to prevent cholera outbreak and spread?

____

____

____

____

APPENDIX III

TABLE 3.2: OUTBREAKS OF CHOLERA EL TOR IN AFRICA

Country	No. of cholera cases reported (or estimated)	No. of Deaths (due to cholera)	Date of incidence
Benin (Dahomey)	407	93	1970
Ethiopia	850	72	1970
French Territories (Afars & Issas)	9	6	1970
Ghana	2733	181	1970
Guinea	2000	60	1970
Ivory Coast	828	39	1970
Libya	350	-	1970
Mali	2902	1199	1970
Niger	16	8	1970
Sierra Leone	293	77	1970
Somalia	43	10	1970
Togo	76	3	1970
Tunisia	27	-	1970
Algeria	109	6	1971
Angola	1	-	1971
Benin	1929	225	1971
Cameroon	2411	352	1971
French Territories	439	69	1971
Gambia	3	1	1971
Ghana	13048	641	1971
Ivory Coast	668	9	1971

Country	No. of cholera cases reported (or estimated)	No. of Deaths (due to cholera)	Date of incidence
Angola	263	9	1973
Benin	3	2	1973
Benin	122	5	1974
Chad	334	92	1974
Ghana	740	39	1973
Nigeria	157	27	1973
Senegal	1987	-	1973
Upper Volta	1114	241	1973
Zimbabwe	154	12	1973
Algeria	9	-	1974
Algeria	16	-	1975
Angola	934	34	1974
Angola	88	3	1975
Benin	63	2	1975
Cameroon	211	7	1973
Cameroon	83	16	1974
Cape Verde	217	20	1974
Comoros	2675	238	1975
Ghana	483	37	1974
Ghana	166	12	1975
Kenya	402	4	1974
Liberia	1336	27	1973
Liberia	512	11	1974

Country	No. of cholera cases reported (or estimated)	No. of Deaths (due to cholera)	Date of incidence
Malawi	1252	-	1974
Mali	130	21	1974
Mauritania	150	22	1973
Mozambique	753	85	1973
Mozambique	361	44	1974
Niger	121	16	1973
Niger	268	75	1974
Nigeria	1585	111	1974
South Africa	35	-	1974
Tanzania	16	-	1974
Togo	58	8	1974
Tunisia	658	-	1973
Upper Volta	632	66	1974
Zimbabwe	738	44	1974
Benin	146	-	1976
Ghana	102	-	1976
Liberia	633	-	1975
Nigeria	38	-	1975
Uganda	4	-	1975
Upper Volta	3	-	1975
Algeria	286	-	1976
Benin	2	-	1977

Country	No. of cholera cases reported (or estimated)	No. of Deaths (due to cholera)	Date of incidence
Djibouti	2	-	1977
Ghana	6558	-	1977
Kenya	440	-	1976
Malawi	667	-	1977
Algeria	2513	-	1979
Benin	27	-	1978
Cape Verde	34	-	1976
Congo	51	-	1978
Gabon	1	-	1977
Ghana	1812	-	1978
Malawi	263	-	1978
Mozambique	1932	-	1979
Nigeria	376	-	1977
Rwanda	838	-	1978
Rwanda	5	-	1979
Senegal	315	-	1978
Swaziland	2	-	1978
Zambia	165	-	1979

SOURCE: WORLD HEALTH ORGANISATION (WHO) STATISTICAL YEAR BOOKS FROM 1971-1981

APPENDIX IV CHOLERA-AFFECTED AREAS

Enumeration Areas	Area (Size in Km^2)	Population (1980 Estimates)	Population Density (Per Km^2)	Cholera Cases 1978–1982	Cholera Cases (Relative Frequencies)	Cholera Incidence Rate (i.e. per 1000 pop.)
Chipungu	95.5	5881	62	88	88/5881= 0.1496	14.96
Puta	208	3863	19	37	37/3863= 0.00958	9.58
Mukunta	359	3630	10	54	54/3630= 0.01488	14.88
Kafulwe	68	2351	35.0	8	8/2351= 0.00340	3.4
Mununga	200	6074	30.4	169	169/6174= 0.02782	27.82
Mwatishi	49.5	3134	63	19	19/3134= 0.00606	6.06
Kashikishi	78	4453	57.1	217	217/4453= 0.04873	48.73
Nchelenge	205	4189	20	556	556/4189= 0.13273	132.73
Kilwa Island	92	3358	36.5	75	75/3358= 0.02233	22.33
Kambwali	170	3425	20	4	4/3425= 0.00117	1.17
Kampampi	75	3353	44.7	13	13/3353= 0.00388	3.88
Chisenga Is.	31	2716	87.6	64	64/2716= 0.02356	23.56
Kawambwa	190	5528	29.1	23	23/5528= 0.00416	4.16
Mbereshi	28	3396	121	54	54/3396= 0.01590	15.9

APPENDIX IV CHOLERA-AFFECTED AREAS CONTD.

Enumeration Areas	Area (Size in Km^2)	Population (1980 Estimates)	Population Density (Per Km^2)	Cholera Cases 1978-1982	Cholera Cases (Relative Frequencies)	Cholera Incidence (18 per 1000 pop.)
Kazembe	12	5528	460	45	45/5528= 0.00814	8.14
Kawama	75	2892	39	88	88/2892= 0.03043	30.43
Lukwesa	80	3502	44	112	112/3502= 0.03198	31.98
Lubunda	61	2312	38	22	22/2312= 0.00952	9.52
Mwense	273	3754	14	23	23/3754= 0.00612	6.12
Kashiba	24	369	15	35	35/369= 0.09485	94.85
Mambilima	22	2037	93	142	142/2037= 0.06971	69.71
Kaputa	13004	70022	5.2	271	271/13004= 0.00387	3.87
Mpulungu	3191	7404	2.3	357	357/7404= 0.04821	48.21

APPENDIX IVA **The Relationship Between Population Density and Cholera Incidence**

Population	R_1	Cholera cases (Relative values)	R_2	di	di^2
62	18	0.01496	12	6	36
19	6	0.00958	10	-4	16
10	3	0.01488	11	-8	64
35	11	0.00340	2	9	81
30.4	10	0.02782	16	-6	36
63	19	0.00606	7	12	144
57.1	17	0.04873	20	-3	9
20	7	0.13273	23	-16	256
37	12	0.02233	14	-2	4
20.2	8	0.00117	1	7	49
45	16	0.00388	4	12	144
88	20	0.02356	15	5	25
29.1	9	0.00416	5	4	16
121	22	0.01590	13	9	81
461	23	0.00814	8	15	225
39	14	0.03048	17	-3	9
44	15	0.03198	18	-3	9
38	13	0.00952	9	4	16
14	4	0.00612	6	-2	4
15	5	0.09485	22	-17	286
95	21	0.06971	21	0	0
5.2	2	0.00387	3	-1	1
23	1	0.04821	19	-18	324

$$\Sigma\, di^2 = 1838$$

$$\text{Spearman's } rs = I - \frac{6 \Sigma di^2}{n^3 - n}$$

Calculated r_s = 0.0919 significant at 95% significant level

APPENDIX IVB **The effect of riverine/lake environment on the outbreaks of cholera**

SAMPLE I		SAMPLE II	
Areas near the river/lake (incidence rates per 1000 of population)		Areas away from the river/lake (incidence rater per 1000 of population)	
x_{ii}	x_{ii}^2	x_i	x_{i2}^2
14.96	233.8016	3.4	11.56
9.58	91.7764	6.06	36.7236
14.88	221.4144	1.17	1.3689
27.82	774.9524	3.88	15.0544
48.73	2374.6129	4.16	17.3056
132.73	17617.253	6.12	37.4544
22.33	498.6289	3.87	14.9769
23.56	555.0736		
15.9	252.81		
8.14	66.2596		
30.43	925.9849		
31.98	1022.7204		
9.52	90.6304		
94.85	8996.5225		
69.71	4859.4841		
48.21	2324.2041		

$\sum x_{i1} = 603.33$ $\sum x_{12} = 28.66$ $\sum x_{12}^2 = 134.4438$

$\sum x_{11}^2 = 498.6289$

Under the assumptions:-

HO: There is no significant difference in the occurrence of cholera in the two samples

H_1: Areas near the river/lake tend to have higher cholera occurrences

$$t = \frac{X_1 - X_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S^2}{n_2}}}$$

testing for difference between means of samples with unequal variances

The calculated t value = 3.98 significant at 1%, 0.5% and 0.25% significant levels.

APPENDIX IVC CONTD.

Enumeration Area (1973 and 1978)	Cholera Incidence	River/Lake Presence
Lubansa	1	1
Kalaba	0	1
Kazembe	1	1
Lwamfwa	0	0
Kawama	1	1
Lukwesa	1	1
Katopwa	0	0
Kapena	0	0
Musangu	0	1
Mulonga	0	0
Lubunda	1	1
Kankomba	1	1
Kashiba	1	1
Kabundafyela	0	0
Mukomansala	0	1
Mulundu	1	0
Mambilima	1	1
Mansa	0	0
Chipili	0	0
Mwense	1	0
Kawambwa	1	0
Samfya	0	1
Sumbu	1	1

APPENDIX IVC CONTD.

Enumeration Area (1973 and 1978)	Cholera Incidence	River/Lake Presence
Kampinda	1	1
Kaputa	1	0
Mbala	1	0
Mpulungu Township	1	1
Yendwe	1	1

APPLY PHI (ø) COEFFICIENT

HO: There is no significant association between presence of river/lake and high incidence of cholera

H_1: There is a significant association.

River/Lake Presence

CHOLERA INCIDENCE

	0	1	
0	A 9	B 10	19
1	C 5	D 27	32
	14	37	51

$$\phi = \frac{AD-BC}{\sqrt{(A+B)(C+D)(A+C)(B+D)}}$$

$\therefore \quad \phi = 0.3439067 \qquad 0.3439$

SIGNIFICANCE

$X^2 = N \times \phi^2$

$$X^2 = N \times \phi^2$$

$$= 51 \times (0.3439067)^2$$

$$= 51 \times 0.1182718$$

$$= 6.0318618$$

X^2 6.0319 - Significant at 5%

APPENDIX IVD THE INFLUENCE OF POPULATION DENSITY ROAD TYPE, URBAN IMPORTANCE AND RIVERINE ENVIRONMENT

Cholera Affected Area	Cholera cases Relative Frequencies	Riverine/ Lake Environment	Population Density	Urban Importance	Road Type
Chipungu	0.01496	1	62	2.729	1
Puta	0.00958	1	19	6.062	1
Mukunta	0.01488	0	10	0.806	1
Kafulwe	0.00340	1	35	0.952.	1
Mununga	0.02782	1	30.4	7.478	2
Mwatishi	0.00606	0	63	1.923	2
Kashikishi	0.04873	1	57.1	11.941	2
Nchelenge	0.13273	1	20	7.478	2
Kilwa Island	0.02233	1	37	1.758	0
Kambwali	0.00117	0	20.2	2.729	1
Kampampi	0.00388	1	45	0.952	1
Chisenga Island	0.02356	1	88	2.729	0
Kawambwa	0.00416	0	29.1	20.091	4
Mbereshi	0.01590	0	121	11.941	2
Kazembe	0.00814	1	461	7.478	2
Kawama	0.03043	1	39	11.758	2
Lukwesa	0.03198	1	44	7.478	3
Lubunda	0.00952	1	38	2.729	3
Mwense	0.00612	0	14	11.324	4
Kashiba	0.09485	1	15	2.729	3
Mambilima	0.06971	0	95	3.174	3
Kaputa	0.00387	0	5.2	4.145	2
Mpulungu	0.04821	1	2.3	7.478	5

Apply Pearson's product moment Correlation:

$$r = \frac{n\sum xiyi - \sum xi \sum yi}{\sqrt{(n\sum xi^2 - (\sum xi)^2 (n\sum yi^2 - (\sum yi)^2}}$$

Calculated $r01 = 0.2788$

$r02 = -0.1339$

$r03 = 0.0245$

$r04 = 0.2244$

APPENDIX IVE <u>THE EFFECT OF TYPE OF ROAD ON THE OUTBREAK OF CHOLERA</u>

	Road type A SCORE (0 - 2)		Road type B SCORE (3 - 5)		
	X_{i1}	X_{ii}^2	Area	X_{i2}	X_{i2}^2
Chipungu	14.96	223.8016	Kawambwa	4.16	17.3056
Puta	9.58	91.7764	Lukwesa	31.43	987.8449
Mukunta	14.88	221.4144	Lubunda	9.52	90.6304
Kafulwe	3.4	11.56	Mwense	6.12	37.4544
Mununga	27.82	773.9524	Kashiba	94.85	8996.5225
Mwatishi	.6.06	36.7236	Mambilima	69.71	4859.4841
Kashikishi	48.73	2374.6129	Mpulungu	48.21	2324.2041
Nchelenge	132.73	17617.253			
Kilwa Island	22.33	498.6289			
Kambwali	1.17	1.3689			
Kampampi	3.88	15.0544			
Chisenga	23.56	555.0736			
Mbereshi	15.9	252.81			
Kazembe	8.14	66.2596			
Kawama	30.43	925.9849			
Kayula	3.21.	10.3041			

Under the assumptions:-

HO: There is no significant difference between the incidence rates of cholera in those areas with major roads and those with minor roads only.

H_1: Areas with better road communication tend to have higher cholera incidence rates.

A student t test for difference between means of samples with similar variance is applied:

$$t = \frac{X_1 - X_2}{\sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1) s_2^2}{\sqrt{n_1 + n_2 - 2}} \times \sqrt{\frac{n_1 n_2}{n_1 + n_2}}}}$$

The calculated t - value = -0.1443, not significant

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