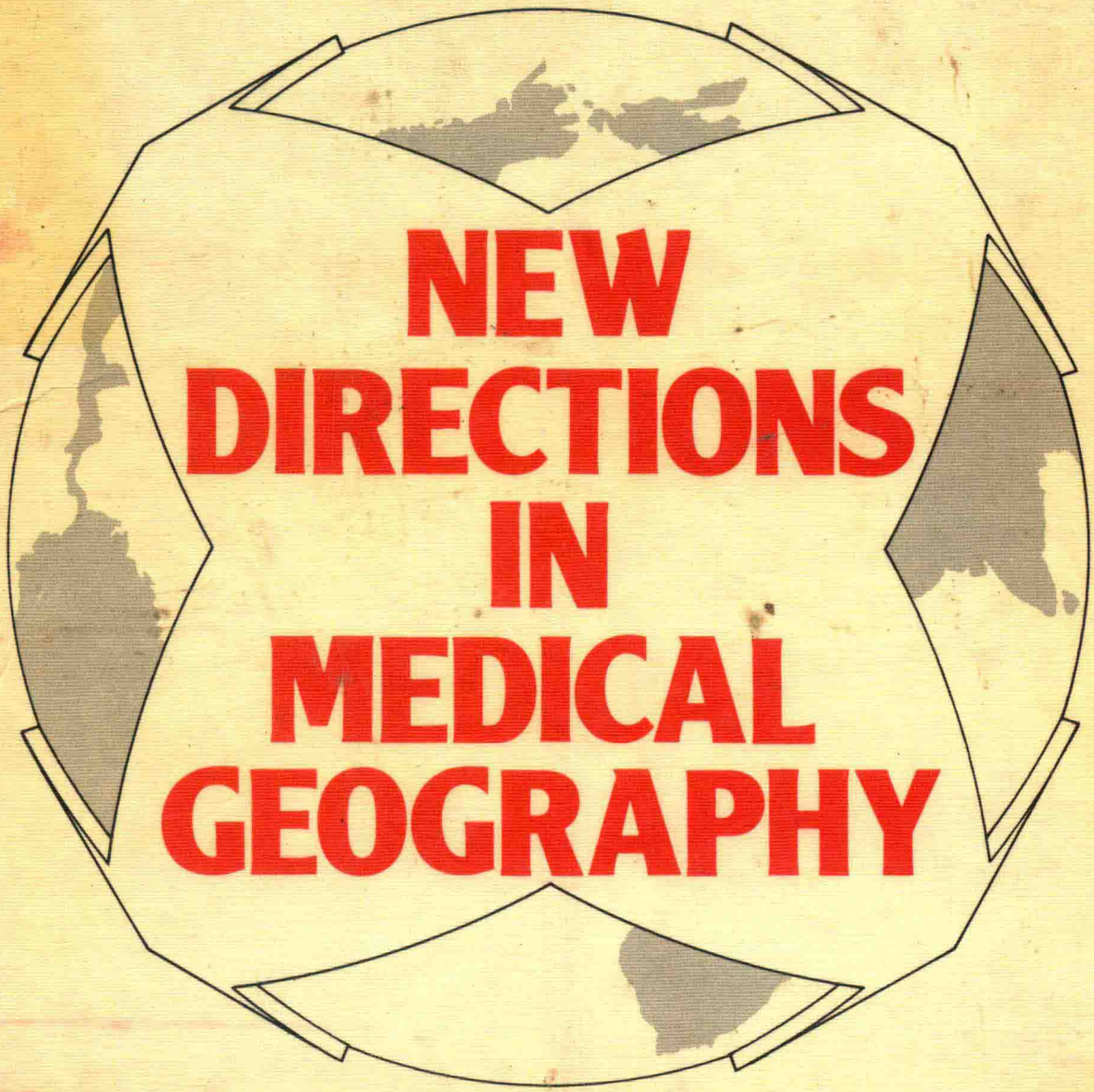

NEW DIRECTIONS IN MEDICAL GEOGRAPHY

Edited by
GERALD F PYLE
University of North Carolina at Charlotte
USA

Pergamon Press

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Medical Geography Papers from the
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GERALD F. PYLE

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EXPANDING NORTH AMERICAN PERSPECTIVES ON MEDICAL GEOGRAPHY

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By the end of the 1970s, contributions by North American geographers in the area of spatial aspects of human health problems had increased at such an exponential rate that previous definitions of the term "medical geography" were expanded to include an increasing variety of conceptual approaches and empirical investigations. This expansion can be attributed to the efforts of many to bring such "fringe area" topics as disease ecology and the geography of health care into the mainstream of geographic research via the use of continuously evolving modern scientific methodologies without the loss of important traditional techniques. As a result of these broadened perspectives, the key to understanding medical geography of the 1980s appears to be the acceptance of diversity without sacrificing meaningful spatial perspectives. The actual diversity has resulted in important exchanges of ideas wherein geographers have moved beyond previously established disciplinary boundaries, applied new analytical techniques to problems in medical geography (thus adding strength within the discipline), and subsequently collectively communicating in a multidisciplinary context to a wider scientific community. Many of the papers developed for five separate medical geography sessions held during the 75th Anniversary Meeting of The Association of American Geographers in Philadelphia in April, 1979 can be considered seminal with respect to expectations over the next decade, while others reinforced important established associations. Since there were more papers presented during the five sessions than could be placed in a single issue of this journal, additional articles will subsequently appear within Volume 14D. The 14 papers selected for this issue have been arranged in a sequence ranging from more traditional field studies to innovative analyses of attitudes and behavior.

FIELD WORK IN DEVELOPING AREAS

Field studies have traditionally been a mainstay in medical geography, and the three contributions in this volume by Matzke, Weil and Gesler demonstrate the need for maintaining such research with continuously improving survey techniques. For example, Matzke's study of trypanosomiasis amongst the Ngindo of Tanzania takes into account disease ecological factors of sleeping sickness as well as migration diffusion resulting from population movement. According to Matzke, one of the most critical factors in understanding the spread of sleeping sickness in similar environments is the actual population density threshhold in settled areas. Weil's study of Bolivian peasants migrating from highlands to tropical lowlands explains how changing dietary patterns affect morbidity and mortality rates. With the development of new highways in the country, many farmers have taken up a pioneering role in previously sparsely inhabited lands, apparently at the expense of the health status of many young children. A community nutrition survey in the Bolivian lowlands indicates that dietary patterns are contributing to these higher youthful morbidity and mortality rates, particularly among females under 5 years of age. With reference to his field experiences in Calabar, Nigeria, Gesler explains some of the factors that can complicate the derivation of illness data from household surveys in a developing area. Gesler explains how questions pertaining to general digestive and respiratory ailments were asked of mothers and children under six who were utilizing the family health clinic of Calabar, and the information gap that exists between their explanations of illness symptoms and the elaborate rubrics of the International Disease Classification System. It is strongly recommended that such household surveys utilize questionnaires that meet such local constraints while at the same time produce reliable and valid information.

NATURAL ENVIRONMENTAL ASSOCIATIONS

Aspects of climate and human health have been documented since the origination of written communication. In an examination of such vital statistics as birth, marriage and death in the United States and Canada, Kevan explores some time-honored notions on the influence of climate. Kevan is particularly concerned about how seasonality affects human behavior; which in turn can lead to various birth and death patterns. His general findings are that while some associations can be uncovered; there appears to be more seasonality with respect to health problems in Canada than the United States. In a more specific empirical study, Miller examines the epidemiology of otitis media within the context of general natural environmental associations, including climate. Miller offers a strong argument in favor of the variable incidence of this type of inflammation of the ear with different weather and climatic conditions, but also suggests a wide variety of cultural and socioeconomic factors requiring further research.

INTERPRETATIONS AT THE STATE LEVEL

Two papers within this volume address the issue of measuring health problems at the state level within

the United States. These studies, by Hugg and Cleek, demonstrate that while there are major shortcomings and limited interpretations involved in medico-geographic analyses of state level data, the researcher need not totally abandon any preliminary comparative studies using that kind of information. In a map comparison using Court's method of cross-classification, Hugg demonstrates the general state-level relationship in the United States between work disability and poverty status. Hugg's research utilizes data obtained from a 1976 survey of income and education. While Hugg's results are preliminary in nature, he does indicate that some of the least affluent states of the nation also have the highest work disability rates. In an examination of various kinds of cancer data at the state level, Cleek explains some of the problems the researcher can encounter when using such information. Cleek presents an exposition of statistical variance and its relation to scale in developing simple and more complicated cancer–environment relationships. The latter contribution should be of particular interest to epidemiologists embarking on geographic analyses.

PROBLEMS IN GEOGRAPHIC EPIDEMIOLOGY

King further addresses the problem of utilization of aggregated data in "casual" studies of epidemiological association, as he takes some of the procedures used in developing the recent atlases of cancer mortality to task in his contribution to this volume. King further addresses many of the interpretive problems associated with generalizations based on broad data aggregations and proposes the further use of probability mapping, autocorrelation and regression testing in future studies of this nature. Continuing to take the methodological bases of many geographical epidemiologies to task, Glick uses the air pollution–environment example to address the problem of inconclusive results in many cancer studies. According to Glick, there are many elaborate theoretical models, but few have been successfully applied in studies of carcinogenesis. He proposes the use of variations of multi-stage modeling in cancer studies and empirically tests distance relationships in the incidence of two kinds of skin cancer. Glick also discusses the pressing need for more multidisciplinary research to end that many of the theoretical models can be tested with the more sophisticated use of principles of spatial analysis. Meade uses multivariate modeling to test the excessive incidence of cardiovascular mortality in the Coastal Plains area of the Southeastern U.S. in her contribution to this volume. Long known as the "enigma area", parts of Southeastern United States Coastal Plains have reported higher than average heart disease mortality rates. While there have been many studies contending that these excessive heart disease rates are directly related to aspects of the geochemical environment, there has been little proof to support these theories. In a discussion of the pros and cons of socioeconomic and geochemical explanations of the enigma area, Meade uses a canonical analysis of socioeconomic variables to explain approximately 20% of the variance, but further suggests that more detailed geographical epidemiologies are required to test geochemical explanations.

STUDIES OF EMERGENCY MEDICAL SERVICES

During the late 1970s, federal health care facilities planning programs in the United States included accelerated efforts to improve the status of emergency medical services nationwide. As with many such planning strategies, a variety of both public and private forms of emergency services delivery were in operation in many locations. While planning efforts are now underway, the general status of such programs at the time of this writing is still manifested by an overall lack of metropolitan coordination in far too many urban areas. National and local funding efforts have increased dramatically recently, but often local politics and efforts to protect vested interests in health care delivery have created many delays in implementing geographically coordinated programs. Due to the very nature of the need for emergency medical services, there is a pressing demand for spatial and temporal data to be used in the planning of more expeditious provision of such health care services. Two studies, one based on public information and the other on private, have been included within this volume as examples of geographical analysis of emergency medical services data that can be used in the planning and implementation of improved health care delivery. In an analysis of 525 cardiac arrest cases handled by the Seattle Fire Department Paramedic Teams, Mayer shows how the minimization of response time can indeed lead to fewer short-term deaths from "heart attack". According to Mayer in his study utilizing public data, a key indicator of reduced deaths from cardiac arrests is the proper geographical placement of EMS vehicles. Mayer points out the critical role geographers can have in the planning and implementation process for emergency medical services. The contribution by Williams and Shavlik utilizes data from a private ambulance company operating in San Bernardino, California to demonstrate that the *overall population* of a census tract used as a planning measurable subarea in emergency medical services is an insufficient indicator of the need and demand for such services. They test use of private ambulance services with income information and show that the demand for services from a few, poorer census tracts greatly exceeds their proportion of the overall population. These two studies of examples of the current use of emergency medical services clearly indicates the need for increased application of geographic principles to such planning efforts.

ATTITUDES AND BEHAVIOR

Many researchers have contended that we will never truly understand many aspects of the geography of health care without developing an expanded awareness of the role of attitudes and behavior. This volume includes the reporting of study results from two teams of researchers: Taylor, Dear and Hall offer a geographical analysis of attitudes toward the mentally ill and neighborhood reactions; and Golledge, Parnicky and Rayner present a methodology for un-

derstanding the spatial competence of mildly retarded populations. Both studies are of methodological importance because they present the careful results of survey research from questionaire-acquired data and the utility of scaling techniques. Taylor, Dear and Hall utilize four attitude scales in a study of neighborhood attitudes toward the location of existing and planned mental health facilities in Toronto. They conclude that overall attitudes toward the location of facilities providing mental health care are generally favorable in most neighborhoods with the exception of limited vocal minorities. Golledge, Parnicky and Rayner offer an experimental design that can be used in many locations to understand levels of awareness and forms of environmental cognition of mildly retarded populations. Both of these contributions also seem to reflect a trend toward societal maturity in understanding the needs and problems of the mentally ill and mildly retarded. The contributions of these two research teams also strengthen the literature of medical geography with respect to empirical conclusions and important methodologies for future studies of attitude and behavior.

RESEARCH DIRECTIONS FOR MEDICAL GEOGRAPHY IN THE 1980s

Clearly, the diverse cross-section of studies in medical geography contained within this volume are indicative of a developing conceptually expanded body of knowledge on medical geography. It is of interest that two important mainstays of contemporary medical geography, studies of disease diffusion and hospital utilization studies, are not included here. Within the United States, the 1974 health planning legislation is still being implemented, and while there is a pressing need for even more geographical information, the efforts of many researchers are now being directed toward problems of policy conflict and accelerated health care costs. There also are some data and policy problems with respect to acquiring reliable disease diffusion information. As studies in medical geography have become more sophisticated and more questions are posed about the reliability and availability of morbidity and mortality information, some policy impediments to the acquisition of information have surfaced. However, most obstacles pertaining to data acquisition in disease diffusion and health care facilities planning studies can be overcome with more persistent efforts on the part of researchers. All of the presumed subareas of medical geography mentioned within this volume are indicative of the directions of research efforts in the 1980s. There will soon be revised general data bases available in the United States and Canada with the release of information from population censuses in the early 1980s. We can therefore expect to see existing and new theories in medical geography empirically tested within the next 5 years. It can also be expected that as our survey research and the use of scaling method improves the 1980s will see the reporting of many more studies of attitude and behavior, both from the developing world as well as from within complex urbanized and industrialized societies. It is anticipated that international cooperative efforts amongst medical geographers and interdisciplinary health-related research teams will also increase in the 1980s. Future special issues of this journal planned for the next 2 years include one issue devoted to medical geography in Australia and New Zealand, another focusing on South and East Asia, and one devoted to papers from the 1980 International Geographical Union Congress to be held in Japan (arrangements have been made with the organizing committee to publish medical geography papers in a special issue of *Social Science & Medicine*, Part D). Indeed, the 1980s can be viewed as an extremely important and productive period with respect to international expansion and cooperation in medical geography.

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SETTLEMENT AND SLEEPING SICKNESS CONTROL—A DUAL THRESHOLD MODEL OF COLONIAL AND TRADITIONAL METHODS IN EAST AFRICA

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Abstract—A traditional system of extreme settlement dispersion acted in concert with homestead abandonment to limit the severity of sleeping sickness outbreaks in S.E. Tanganyika. Changes during colonial times fostered settlement agglomeration and the disease became a major public health problem. Colonial control policies required a program of density intensification to achieve total environmental control. This high density settlement pattern was dysfunctional to the Ngindo people and the new settlements were rapidly abandoned. A study of this epidemic suggests that there is a range of settlement densities which are especially favorable to sleeping sickness outbreaks. Although high densities of settlement have long been recognized as deterrents to epidemics, this paper suggests there is also a low density condition which retards epidemic outbreaks.

INTRODUCTION

The story of man's struggle with African sleeping sickness (trypanosomiasis) is still being written. The published record of investigations focusing on the disease is now nearly a century old, but huge gaps in our understanding still exist. One of the biggest gaps is in our understanding of the etiology of sleeping sickness epidemics.

The proximate cause, the infective bite of a tsetse fly, is not in question. Rather, the ultimate cause, the condition which stimulates an outbreak in a particular locality, is in debate [1].

Two somewhat exclusive schools of thought can be discerned. The most easily understood centers on the hypothesis of migration. If one accepts this view, each new outbreak is the result of the movement of infected persons from established foci of the disease. (Fig. 1) Medical investigators interview individuals and establish a history of movements linking one individual with another whenever possible. When detailed evidence is lacking, guestimates are often recorded suggesting that returning house servants, soldiers, or other unidentified travelers introduced the sickness from a known sleeping sickness focus.

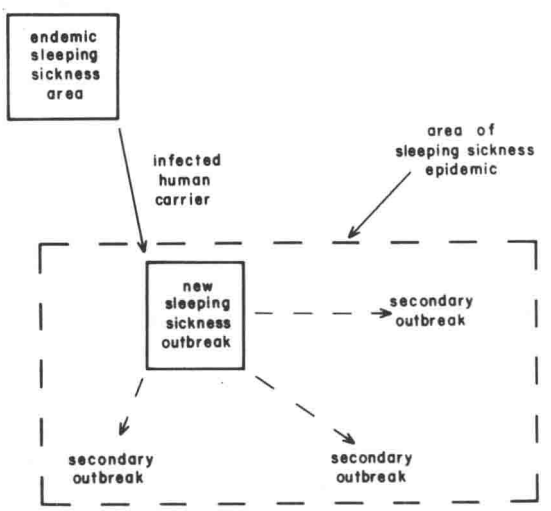

Fig. 1. Migratory thesis. Sleeping sickness outbreaks are explained by the movement of infected persons from established foci of the disease.

A second explanation, the ecological hypothesis, suggests that sleeping sickness epidemics occur when the operative ecological control mechanisms are manipulated and latent endemicity is metamorphosed into blatent epidemicity (Fig. 2). In this view, quantitative changes in the populations of man, domestic livestock, and wild fauna give rise to ecological conditions which are favorable for populations of tsetse and trypanasomes prior to a sleeping sickness outbreak. When human targets are present, the "critical mix" is complete and the potential for an epidemic exists.

It is the intent of this paper to examine the case of a sleeping sickness outbreak in East Africa for evidence which sheds light on these theses. In addition, it will be suggested that colonial attempts to manage the epidemic were based on a completely different understanding of ecological control than that of the traditional peoples of the area. This resulted in a rapid dissolution of colonial control over the disease environment.

BACKGROUND

The study area is located within the boundaries of the Selous Game Reserve in the country of Tanzania (Fig. 3). Although it is now uninhabited, this was not always the case. A complete settlement history is available elsewhere, but a review of a few important elements is essential [2].

The study area inhabitants, the Ngindo people, lived in scattered settlements separated by considerable expanses of uninhabited bush during the latter part of the 19th century. Within these dispersed people, there was no supraclan political system to organize for mutual defense. They were vulnerable to

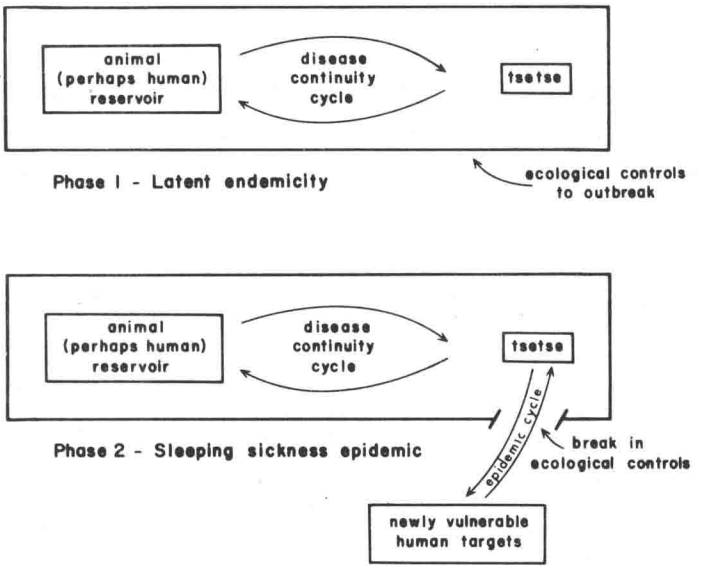

Fig. 2. Ecological thesis. Sleeping sickness is controlled by ecological mechanisms which allow it to persist in area without causing an epidemic during Phase 1 conditions. Under Phase 2 conditions, the ecological controls are breached the relatively innocuous endemic disease spreads with the contagion of an epidemic.

harassment by better organized intruders. In these circumstances, a cultural system evolved which maximized settlement dispersal. People abandoned homesteads whenever they felt threatened. Maximum isolation was their defense strategy. No settlement agglomerations of note evolved.

The imposition of German colonial rule thinned out human occupance even further. The Maji-Maji rebellion broke out in 1904. It was ruthlessly repressed with a scorched earth policy that brought on a 3-year famine. Soon thereafter, World War I raged through the area and the remnant peoples suffered further deprivation and loss of life. Each new wave of trouble reinforced in people the need to be inconspicuous by dispersal far from even such modestly attractive locations as water sources. Population densities by the start of English rule after WWI were only about 1 person per square kilometer over a huge area of tsetse infected countryside.

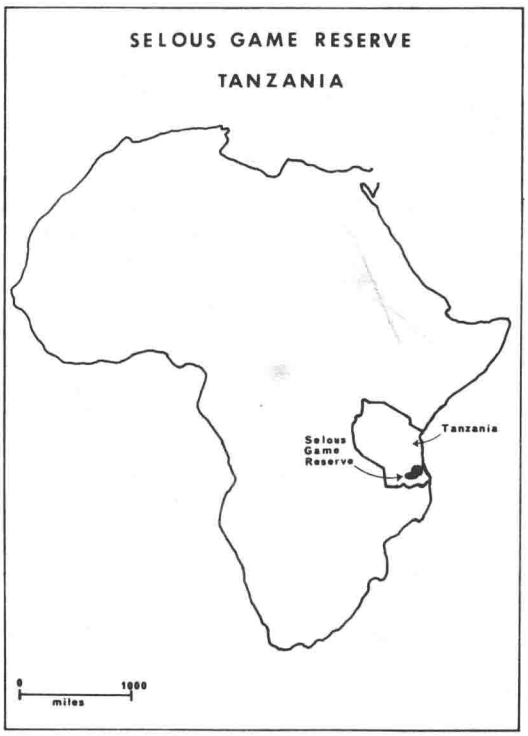

Fig. 3. The Selous Game Reserve in Tanzania.

The advent of "Pax Britannica" facilitated the evolution of a new settlement pattern. With the encouragement of the colonial government, the persistence of peace, and the natural advantages of proximity to water and fertile soils, a slow movement of people into broken linear settlements along watercourses took place. Although nothing approximating village agglomeration was the norm, the population density within fertile river valleys was certainly up to 20–25 people per square kilometer in places by the mid-1930's. The historical antipathy toward nucleated settlements was retained as most houses were out of sight of each other and 10–15 mile gaps without houses were common.

The new settlement pattern did nothing to break the people's contact with the tsetse fly. Wild vegetation was continuously present within close proximity to the settlements and the tsetse's habitat was thus preserved. Under these conditions, a sleeping sickness epidemic occurred.

THE MADABA OUTBREAK

An initial examination of the archival record of this disease outbreak gives strong support to the migratory thesis of sleeping sickness epidemics. The outbreak, focused on the Madaba area, was pieced together by a British sleeping sickness officer about 1 year after it started [3]. He demonstrated that the

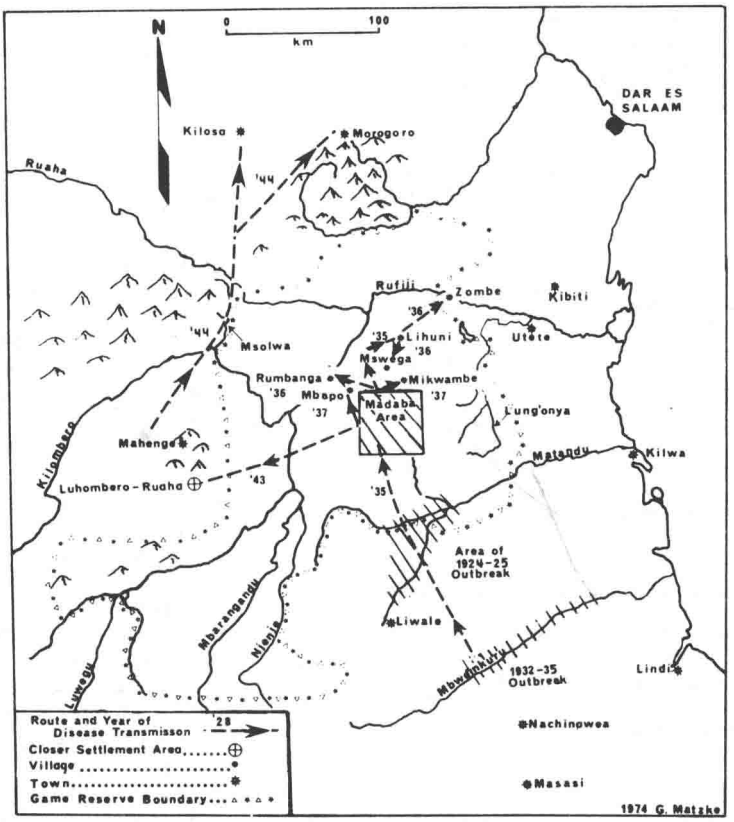

Fig. 4. Spread of sleeping sickness in southeastern Tanzania. The map of recorded first cases of sleeping sickness associated with the Madaba outbreak suggests support for a migratory origin of the disease.

initial contact with an outside disease focus was made by a man's visit to relatives. Thereafter, a visit to one victim's funeral became the link to the next person's death as the disease spread in the classic migratory fashion (Fig. 4). For the first few years, it was contained by quarantine to within a 100-kilometer radius. Eventually, however, the confinement boundaries were breached and migrant workers broke out with cases in far distant places. The quarantine strategy had failed to contain the outbreak.

COLONIAL CONTROL POLICIES

The persistence and spread of the Madaba epidemic forced the colonial authorities to rethink their control measures. It was decided that a "closer settlement" regime was needed. This was the first attempt at such a concentration in southeastern Tanzania, although it had been tried with considerable success elsewhere [4].

The theory behind the concentration of people into compact areas is simple. Generally speaking, the more open the country, the less suitable it is as a breeding habitat for tsetse flies which require shade [5]. Tsetse usually will not cross cleared barriers of 3 kilometers in width (Fig. 5). Since it is impractical to maintain a cleared strip of this width around isolated hamlets, the hamlets are consolidated into one location. In this location, the juxtapositioning of fields keeps some areas fly-free and a cooperative effort of bush clearing can completely free the remainder of tsetse infestation. With no vectors available to transmit the disease, the continuation of the sleeping sickness cycle is impossible and the disease disappears in the human population.

The sleeping sickness authorities recommended that initial densities of 30–40 families per square kilometer were advisable in the concentration areas. This could gradually be reduced to 15 families as reclamation progressed [6]. New concentrations of less than 1000 families were considered unsatisfactory since it was unlikely that more than 10 hectares per family could be maintained bush free in miombo country [7]. Settlements of the "ribbon type" were to be avoided in favor of those growing equally in all directions from a center point.

The British perception of the disease environment and appropriate control measures is modeled in Fig. 6. In their view, the historical oscillation of populations within the study area inevitably kept the people living at a density which was hazardous for sleeping sickness. In the absence of traditional agglomerations of high density, it was necessary to impose them on the people. This was done during the 1940's and the Selous Game Reserve was created on abandoned lands to prevent resettlement.

Human sleeping sickness disappeared from the Madaba area because the people disappeared. The epidemic ran its course because infected people were isolated from the tsetse along with all potential new human targets. This reading of history vindicates the

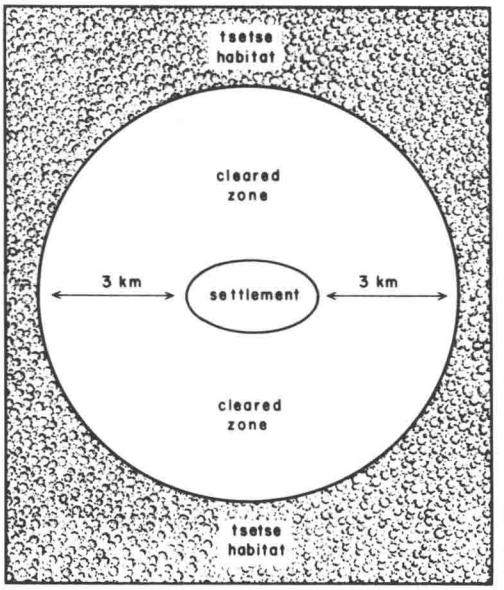

Fig. 5. Closer settlement isolated from tsetse habitat. The "closer settlement" schemes for sleeping sickness control operated on the principle of isolating people in villages surrounded by a tsetse free zone of cropland and cleared land. Isolated from the tsetse vector, the disease could not be transmitted and the epidemic died out.

migratory thesis of sleeping sickness epidemics. It is not, however, the complete story.

TRADITIONAL CONTROL POLICIES

The migratory thesis is a problematic explanation for the events in the Madaba area for several reasons. The foremost of these is the presence of the disease in the vicinity at least several times prior to the epidemic outbreak in 1935. The local language had a word for it, *uvimbe*, or the swelling disease. This suggests it was not a recent innovation brought from far away. German medical officers found cases south of Madaba prior to WWI as an outbreak was identified in the same area in 1924–25 (Fig. 4). A medical officer visiting the scene reported that:

> Inquiry among the more intelligent natives elicted the fact that this type of outbreak has occurred before, not once, but frequently in the past [8].

Apparently, a mechanism existed for control of the disease before it reached epidemic proportions. This control was only partial because the disease persisted, but it was achieved without isolation from the tsetse vector.

The archival record of traditional activities yields some clues which suggest support for the ecological thesis of sleeping sickness outbreaks. The early medical investigators noted that the people in the area reacted to this natural scourge in the same way they had to threats from human quarters. They abandoned their homes and took up a new life elsewhere. The disease usually disappeared. The evidence from Table 1 is illustratory. Of the 10 villages involved in a 1925 outbreak, all but one either disappeared or declined substantially in size by 1936.

The traditional response to the sleeping sickness scourge was diametrically opposed to the concentration schemes of the British. The Ngindo peoples' view of appropriate control measures is modeled in Fig. 7. In this view, the correct response to an outbreak was settlement dissolution, not concentration. The perceived threshold of safety from sleeping sickness was a very low density one, not the high density safety threshold recognized by the British.

DISCUSSION

The Madaba sleeping sickness epidemic arose during a time of changing human settlement behavior. The long standing system for maximizing dispersal was slowly abandoned with the arrival of the British colonial presence. There was a gradual rationalization of settlement in the resource rich river valleys. As the population density within these settlement locations increased, it crossed a threshold which the Ngindo

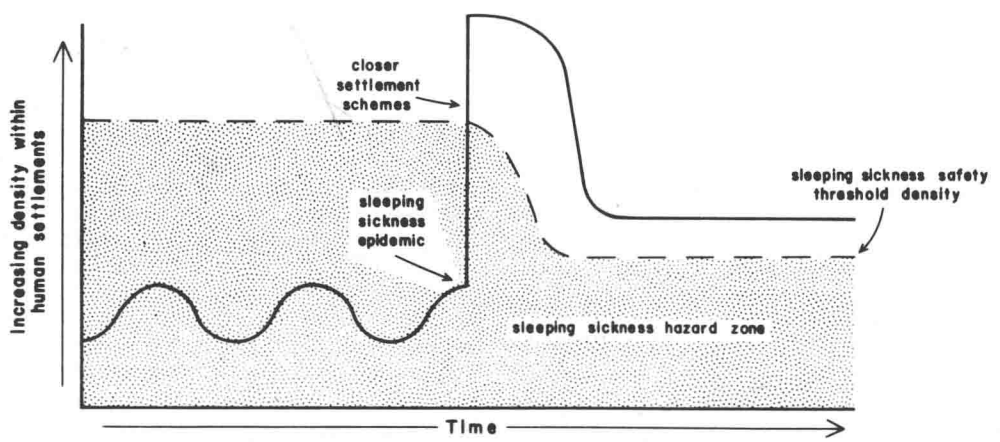

Fig. 6. Colonial view of settlement control of sleeping sickness. The British perception of the sleeping sickness hazard assumed that low density settlements were hazardous because they could not control the tsetse habitat. Their closer settlement program forced people into high density settlements which removed tsetse habitat and then allowed for some relaxation of settlement densities since lesser numbers of people could maintain cleared areas.

Table 1. Population changes in villages reporting sleeping sickness cases during the 1924–1925 epidemic

Village	Sleeping sickness			Population*	
	Deaths	Others	Total	1925	1936
1. Muhungo	9	8	17	250	120
2. Namaganga	6	12	18	174	×
3. Namabao	42	26	68	115	72
4. Kiringulia	8	1	9	66	36
5. Ali Kupawiro	1	5	6	60	×
6. Muhambia	0	1	1	60	×
7. Nambrikwe	0	1	1	60	×
8. Nameno	0	1	1	54	×
9. Mohoro	1	2	3	52	×
10. Liwale Chini	0	4	4	39	84

* The 1925 figures are estimates of a sleeping sickness officer on the scene. The 1936 figures are the number of taxpayers multiplied by 3 which is a generous conversion based on the author's comparison of the taxpayer data and population size in the provincial records.

× Village no longer in existence.

Revised from: A report by H. Fairbairn, Sleeping Sickness Officer on tour in Liwale District, November 2, 1936. This report is available in the Tanzania National Archives File 61/104.

people had always viewed as unsafe. When an outbreak occurred, the colonial policy of concentration based on the high density safety threshold was frustrated by the traditional perception of the low density safety threshold. For a 10-year period ending with the forced abandonment of the entire area, the epidemic continued. The British consolidated people but never sustained densities and cooperation adequate to control the tsetse bush. The Ngindo no longer had the freedom to maximize their dispersal potential. By everyone's definition, they lived at hazardous densities.

The issue remains as to whether or not there is any rational basis for a low density safety threshold acting to suppress epidemic outbreaks. There are two possible lines of support. If the migratory thesis is true, some might argue that village abandonment and population dispersal exacerbates the problem by pushing carriers into uninfected locations. It is possible, however, that extremely low densities of potential new human targets limit the chances of the disease spreading by limiting contact between vectors and victims. Nash reports that less than 1% of the flies become infective after biting an infected host [9]. The rare infective fly seeking new targets under conditions of scarcity finds it difficult to sustain a contagion.

The conditions described above also serve to limit contagion if the ecological thesis is true at least insofar as the spread after the initial case of the disease is the result of a cycle of man → fly → man infection. If the disease is somehow a latent part of an area's environment (as in Phase 1 of Fig. 2), low density human may be an operative ecological control mech-

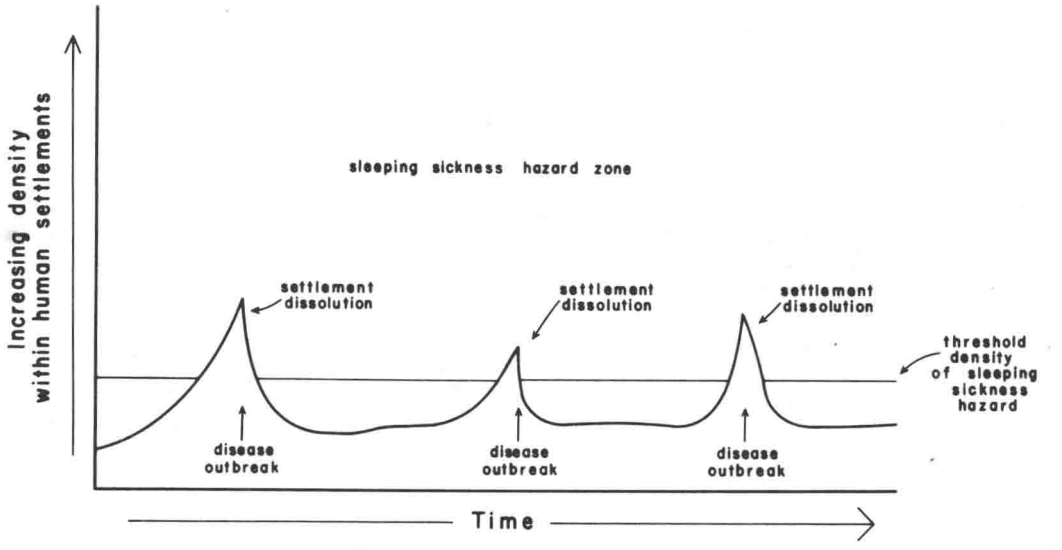

Fig. 7. Traditional view of settlement control of sleeping sickness. The Ngindo people viewed the outbreak of sleeping sickness as a bad omen which resulted from their settlement circumstances. Their response was to dissolve the insipient agglomerations and disperse at much lower densities which were below the sleeping sickness hazard zone.

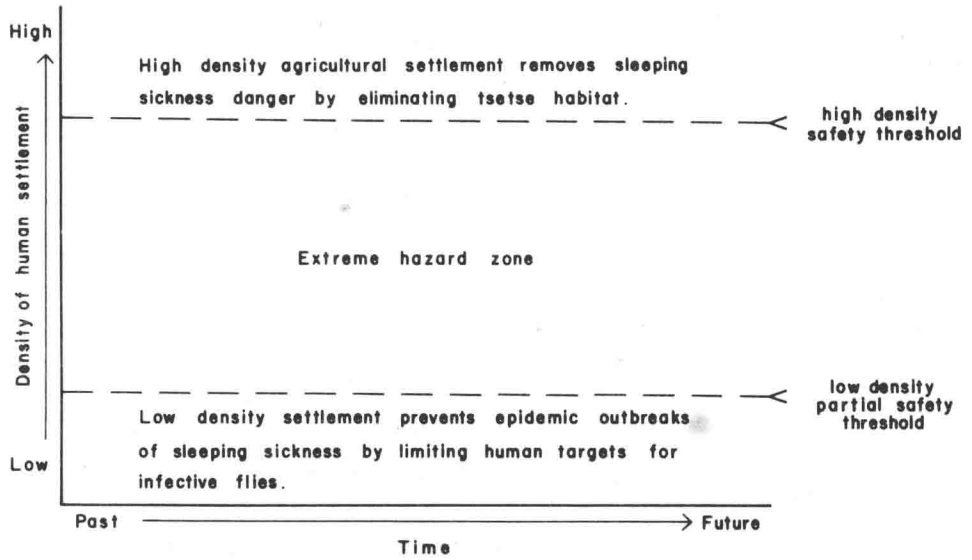

Fig. 8. Dual threshold model of sleeping sickness control. This diagram illustrates the author's view that sleeping sickness epidemics are unlikely at both low and high densities. The colonial government's response to outbreaks was to force people into high density situations. The Ngindo people's traditional response was to dissolve settlements and seek safety at low densities.

anism. The shift to higher settlement densities breaks down the control (as in Phase 2 of Fig. 2) by increasing the ease with which a vector finds its victim.

The examination of the Madaba sleeping sickness epidemic indicates that the ecological explanation of events is a superior description of epidemic causation if it is enhanced with a duel threshold model as shown in Fig. 8. Conditions suitable for epidemic outbreaks of African sleeping sickness arose when human settlement densities were within an extreme hazard zone. Below that zone, infective vectors and potential victims had few opportunities for contact. Above the hazard zone, the vector was eliminated by habitat manipulation and the removal of the supportive wild animals needed to complete the tsetse life cycle.

The utility of this model is enhanced if quantitative judgements are made which define both the upper, and lower, safety thresholds. With these as a guide, researchers may test it against other epidemic circumstances to determine the validity of the model. The upper limit is most easily established and was tested in many control operations by the colonial government. After a site had effectively been occupied, 15 families per Km^2 could keep the landscape tsetse free. The lower limit suggested in this paper is more problematic. Within the Madaba study area, sleeping sickness was controlled when people lived at overall densities of about 0.3 families per Km^2. Since they were not uniformly distributed, it is likely their within settlement densities were considerably higher. Based on the scarcity of locations suitable to settlement, it is likely that densities within settlements were between 2 and 3 families per Km^2. The sleeping sickness hazard zone-would start somewhere above this level of density [10].

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MORBIDITY, MORTALITY AND DIET AS INDICATORS OF PHYSICAL AND ECONOMIC ADAPTATION AMONG BOLIVIAN MIGRANTS

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Abstract—Bolivian peasants are migrating from marginal farming areas in the highlands to newly accessible settlement areas in the tropical lowlands. Local census health data and a community nutrition survey indicate that the migrants have a better diet and participate more in the market economy than do peasants in the highlands, but probably at the expense of a higher toddler mortality rate among their children.

INTRODUCTION

Traditional farming areas in many low-income countries are characterized by excessively small landholdings, underemployment, and poverty. One result is massive rural–urban migration. Yet the cities are ill-prepared to absorb the new arrivals, and most of the migrants are ill-prepared to compete for the few jobs available. The cities are characterized by crowding, unemployment, and the poverty of slums.

Several of the low-income countries in Latin America and other parts of the world have extensive sparsely settled areas, especially humid tropical lowlands. As new highway construction links these to populated areas, people migrate to establish farms there. This provides at least some temporary relief of the tensions resulting from population growth under conditions of limited access to land or jobs in the traditional farming areas and the cities.

Many studies have attempted to evaluate the success, or adaptiveness, of resettlement by small farmers in tropical lowlands. Most of these have evaluated government-directed migration and settlement, although throughout Latin America spontaneous settlement accounts for the great majority of migrants. Most studies evaluate the success of new settlement in strictly economic terms, usually by whether the government investment in a project pays off in terms of income generated by increased agricultural production [1].

This is a valid way to evaluate projects, but it addresses only a small part of the settlement process. Increased agricultural production in new settlement areas is frequently the result of large-scale commercial agricultural enterprises which benefit more than do small farmers from infrastructure such as new roads, electrification and technical assistance. In addition, the goals of small farmers and governments are not necessarily the same, and the short-term and long-term goals of either or both often are not congruent. Given these complexities, defining "success" in a new settlement area is difficult; finding data to evaluate any aspect of it is equally challenging. This paper, based on fieldwork in Bolivia from 1975 to 1977, uses a case study approach to evaluate the adaptiveness of new settlement from the small farmers' point of view along several parameters. Fieldwork yielded several types of data; reported here are the results of health interviews and a nutrition survey.

Bolivia lies within the latitudinal tropics, but its extreme variations in altitude produce a great variety of environmental zones. Since prehistoric times, the human population has been concentrated on the *altiplano*, a high plateau which extends the length of the country, and in the high Andean *valles* (see Fig. 1). However, about 60% of the national territory is made up of lowlands east of the Andes. The department of Cochabamba, where fieldwork was conducted, contains some of each of the three major regions.

Farmers from the Cochabamba valley, mainly from marginal agricultural areas, have been migrating to the nearby tropical Chapare lowlands for decades, but the trickle of migrants became a steady flow when an improved road linking the highlands and lowlands was completed in 1971. There are now about 33,000 people in the lowland portion of Cochabamba department, about 4% of the department's population [2, 3]. Over 80% of the lowland population is made up of spontaneous settlers and their families [3].

MORBIDITY AND MORTALITY

Historically, diseases have been an important deterrent to settlement of the tropical forests of lowland South America by highland peoples and Europeans [4, 5]. One of the greatest disease threats, malaria, was eradicated from the Bolivian tropical settlement areas between 1950 and 1955 [6]. Several observers have predicted that new settlement will exacerbate disease problems by disrupting the tropical forest ecosystem and by bringing human populations into contact with little known disease agents [5]. A survey of health problems in one community in the Chapare, however, indicates that the poor health status of the settlers is due largely to intestinal parasitosis and associated anemia, problems which are common in the tropics and well understood but persistent.

In the community of spontaneous settlers where the data reported below were collected, there is no potable water supply; water is used directly from streams and even stagnant ponds. There are few latrines, and these are open shallow pits. The consequences of the poor sanitation practices brought from