INCIDENCE OF DIARRHOEAL DISEASE AND ASSOCIATED MORBIDITY RISK MARKERS IN PORT DICKSON DISTRICT, MALAYSIA

INCIDENCE OF DIARRHOEAL DISEASE AND ASSOCIATED MORBIDITY RISK MARKERS IN PORT DICKSON DISTRICT, MALAYSIA

BY

TRACEY VANSICKLE, B.A. (HONS)

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree

Master of Arts

McMaster University

August 1988

MASTER OF ARTS (1988) McMaster University
(Geography) Hamilton, Ontario

TITLE: Incidence of Diarrhoeal Disease and Associated Morbidity Risk Markers in Port Dickson District, Malaysia

AUTHOR: Tracey Vansickle, B.A. (Hons) (McMaster)

SUPERVISOR: Dr. S.C. Lonergan

NUMBER OF PAGES: viii, 132

ABSTRACT

Due to the increasingly documented prevalence of diarrhoeal diseases in Malaysia, a number of water-related programmes have been implemented in an attempt to improve health status through the reduction of incidence of waterborne communicable diseases associated with poor public water supplies. The implicit assumption underlying these projects is that the enhancement of the physical infrastructure, and subsequent improvements in the quality of the water supply, will substantially reduce water-related disease. This thesis questions the veracity of this hypothesis, and therefore the justifiability of an emphasis upon engineering and urban infrastructural interventions.

Research centred upon Port Dickson, a district which typifies existing water and sanitation conditions in much of semi-rural Malaysia. The specific objectives of the thesis were: to determine the measured burden of illness of waterborne disease within the district and to estimate levels of underreporting; to determine morbidity-related factors influencing the decision to seek medical treatment; to provide a demographic profile of the population experiencing diarrhoeal episodes; and to identify risk markers or predictors of morbidity. Burden of illness was measured by health services utilization, while values for underreporting and risk markers were derived from a 268-household diarrhoeal morbidity survey.

Diarrhoeal incidence was estimated to be 12-16% annually, much higher than Malaysia's official average. This incorporated a rate of non-reporting of 19%, which was influenced by chronicity, duration and severity of episodes. Individuals found to be most at risk were young children and adults in their child-bearing years, minority racial groups, and those with poor water supply and sanitation infrastructure and inappropriate hygiene habits. While water quality was found to influence diarrhoeal rates, factors in addition to infrastructure - particularly hygiene - were shown to play a greater role. Thus, it is suggested that the impact of water and sanitation improvement projects would likely be minimal, unless accompanied by complementary behavioural education programmes. The spatial bias of the aforementioned risk factors suggests a need to refocus intervention initiatives upon rural areas.

ACKNOWLEDGEMENTS

This thesis is dedicated to Mr. Gilbert Dionysius, a man of integrity and generosity; and to Mr. Madhu Sudan Dutta, to whom I owe a debt that can never be repaid. There are no words to express my gratitude to you both.

I am grateful to all who helped to ensure the success of my fieldwork in Malaysia. In particular, I would like to thank Dr. Prasanna Nair, Dr. Chi Seck Choo and Ibrahim Nather Khan for their assistance; Jothi Malar Panandam for her friendship; and Vicky and Georgette for their support and care packages.

I am also grateful to Dr. Bill Anderson for his advice and the use of his already overburdened computer, to Dr. Yorgo Papageorgiou for his encouragement and several enjoyable years of teaching experience, to my academic supervisor, Dr. Steve Lonergan, and to Rosanna, for all of the little things over the years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 The Research Problem

Diarrhoeal disease remains the leading infectious cause of infant and child mortality and morbidity in many developing nations. Up to one billion episodes[1] of diarrhoea yearly affect children under five years of age[2] in Asia, Africa and Latin America (Foege and Henderson, 1986). The mortality rate has been estimated to be as high

---

[1] An episode is herein defined as an attack of diarrhoeal illness which tends to recur at intervals, and comprises increased frequency and liquid consistency of stools (and may involve other symptoms, such as blood or mucus in stools, fever, and vomiting). As will be discussed later in this thesis, definition of diarrhoea is somewhat arbitrary, since many studies use different criteria while a large number give no definition at all. This raises some question as to the accuracy of incidence estimations. Also, where morbidity has been self-reported, the term has not always been culturally operationalised, although cultures define diarrhoea differently.

[2] Walsh and Warren (1979), extrapolating from estimates from the World Health Organization (Special Programme for Research and Training in Tropical Diseases) and published population-specific epidemiological studies, estimated that the total morbidity burden for all ages in these regions ranged from three to five billion infections per year.

as one in ten for children in this age group[3] (Population Information Program, 1984), and diarrhoeal diseases have been found to account for more than one-third of paediatric deaths (World Health Organization, 1979a;b) in parts of these regions (see Table 1.1). Considering that in many parts of the Third World, deaths among children constitute from forty to sixty percent of all deaths in the population (Walsh and Warren, 1979), the enormity of these totals alone emphasizes the need for immediate and effective efforts to reduce mortality and morbidity caused by acute diarrhoeal disease. When considered in tandem with the residual impact upon children surviving disease episodes, such as retarded growth and impaired quality of life, the magnitude of crisis is almost incomprehensible. There exist significant adverse physical, mental and social disabilities accruing from the synergistic relationship between diarrhoeal infection, and malnutrition and dehydration: often these will persist in the affected

---

[3] Snyder and Merson (1982) suggest a more conservative figure. They estimate that diarrhoeal disease results in 1.4 deaths and 220 diarrhoeal episodes per hundred children per year in developing countries (excluding China). This translates into nearly five million deaths per year.

This mortality rate may be an underestimation, since most disaggregate rates were derived from studies involving active surveillance, implying that individuals monitored had easier access to medical intervention. Morbidity rates tend to be more accurately reported than previously, however, since surveillance also implies more complete recording of relatively mild episodes.

population throughout their lifespan (Jellife and Stanfield, 1976). This synergism also lowers the general health status of the afflicted population. The resultant increased susceptibility of young children to multiple pathological influences and, therefore, increased mortality and morbidity from other causes, places an unmanageable burden on health care systems. More significant, however, is the "hidden burden" of diarrhoeal-effected poverty, deprivation, debility, and the inability of surviving children to achieve their social, cultural and genetic potentials (Taylor et al., 1985a).

TABLE 1.1

Percentage Contribution of Diarrhoea to Paediatric Mortality, Selected Regions

Region	**Percentage**	**Source**
Caribbean	35	Myers, 1982
Central America	26	Mata, 1983
Gambia	30	McGregor et al.,1970
Haiti	40	Isely, 1982
Malaysia	11	Chen, 1984
North America	.9	Mata, 1983
Punjab	44	Agarwal, 1979
South America; tropical	22	Mata, 1983

Diarrhoeal diseases are ranked third amongst the principal causes of death in pre-teen Malaysians (Lo, 1985). In one of the country's largest hospitals, the percentage of paediatric admissions is consistently greater for diarrhoea than for respiratory infections (Mohan, 1985). In the infectious diseases ward of Kuala Lumpur's General Hospital, more than ninety percent of cases admitted are severe cases of diarrhoea (Yap[4], 1985). Dr. E.K.C. Lo, Assistant Director of Health in Kuala Lumpur, emphasizes that Malaysian figures for the annual incidence of gastroenteritis are significantly greater than the official estimated average of thirteen per thousand population. This is due to four factors: statistical information is available only from government hospitals, clinics and health centres and therefore excludes private practitioners; rates of under- and non-reporting are extremely high[5]; terminology (for instance, the use of gastroenteritis versus diarrhoea versus food poisoning) is not standardized; and specific diseases such as cholera, dysenteries and typhoid are often excluded from

---

4 Dr. Yap is currently engaged in a study on rotaviral isolation and incidence for the World Health Organization. Preliminary investigations of the distribution of acute diarrhoea patients (tested) by type of infection suggest that rotavirus (as opposed to bacteria) is responsible for at least thirty percent of hospitalized cases (Othman, 1985). While this percentage has been found to be much smaller in some community-based studies (Yap, 1985), there is evidence that it increases to as much as sixty percent during diarrhoeal epidemics (Lam, 1985; Othman et al., 1985).

5 The Sewerage and Drainage Systems Master Plan for Seremban (Government of Malaysia, 1982) suggests that water-related infectious diseases in Malaysia are underreported by as much as a factor of twenty.

gastroenteritis returns (Lo, N.D.).

Due to the increasingly documented prevalence of waterborne diseases in Malaysia, the federal government has established a National Drinking Water Quality Surveillance Program, with the principal objective of raising the standard of health by ensuring the safety and acceptability of the drinking water (Ministry of Health, 1983a). This is to be achieved by reducing the incidence of waterborne communicable diseases associated with poor public water supplies. The state of Negri Sembilan has been the pilot project area for this program since August of 1984.

The joint Universiti Malaya - United Nations University Linggi River Water Resource Management Project was developed in the early 1980's in part to examine the role of water supply and quality in regional growth. The Linggi watershed, comprising the Negri Sembilan districts of Seremban, Port Dickson and Rembau, has been targetted as the next major area of development in Peninsular Malaysia. The project investigators considered present and future water supply and quality problems, and proposed regional economic and industrial development scenarios. They concluded that the rapid deterioration of water quality in the basin's rivers may inhibit regional industrial development. It also became clear that, in turn, the negative consequences of such development on water supplies have implications for future water management and regulation, and particularly for the health status of the population.

Similarly, the Seremban municipal sewerage and drainage systems master plan aims to significantly decrease faecal coliform levels in the Linggi River through the improvement of sanitary and environmental conditions in order to "substantially reduce the present public health threats associated with the usage of the Sg [River] Linggi for the primary source of water supply in Seremban and Port Dickson" (Government of Malaysia, 1982, p. 1-7). The central sewerage system designed to achieve this goal will serve a projected population of 275,000 people, at a total cost of 243 million ringgit [approximately $112 million Canadian].

All of the aforementioned programmes predicate a clear connection between health status and water quality. However, they fail to consider the complex interaction of biological, environmental, social and behavioural determinants which ultimately impact upon the health status of the population. The implicit assumption behind such projects is that enhancement of the physical infrastructure, and subsequent improvements in the quality of the water supply, will substantially reduce the health burden within the impacted region.

One objective of this thesis is the determination of the veracity of this hypothesis. The research focusses upon Port Dickson, one of the three districts within the Linggi River watershed, and a recipient of the consequences of the above interventions. Port Dickson was chosen and the other districts excluded both to make the study of manageable proportions, and because of the willingness of health professionals to supply sensitive data.

1.2 Research Objectives

The objectives of the study are four-fold. Firstly, records of documented diarrhoeal episodes from Port Dickson will be employed to determine the measured burden of illness of waterborne communicable diseases within the district. The study will emphasize morbidity as a measurable disease outcome since mortality is an inappropriate indicator of health status in this particular region. Infant and child death rates have declined substantially, and non-paediatric diarrhoeal mortality represents an insignificant proportion of illness burden within the population. Unfortunately, health services utilization data by its very nature incorporates an accessibility bias, and has the potential to exclude a large segment of the population. Therefore, data derived from a household diarrhoeal morbidity survey will be used to estimate levels of non-reporting in order to provide a more accurate measure of total incidence.

Secondly, a brief outline of diarrhoeal episodes and morbidity-associated factors (such as severity and duration) will be presented, and an attempt made to determine which, if any, of these factors influence the decision to seek medical treatment and hence, the level of underreporting.

From the incidence data can be derived a demographic profile of the population suffering from diarrhoeal episodes: the ethnic composition; the distribution of incidence by age or sex; and the correspondence of this with the distribution of the general population by the same categories. Variations among ethnic groups, either in total share of diarrhoea or in the morbidity patterns among age groups, will also be examined, as will distribution of various forms of water supply.

Lastly, the thesis will investigate risk factors associated with increased probability of diarrhoea. Levels of association or significance of various risk markers or predictors of morbidity with self-reported diarrhoea will be determined. The district's water supply and sanitation infrastructure and behavioural practices will be briefly outlined. With reference to those factors found to be relevant, conclusions will be drawn regarding the appropriateness of existing interventions against diarrhoeal diseases within this district, and the justifiability of the current emphasis by the Malaysian government upon "engineering" and infrastructural solutions.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1 The Model

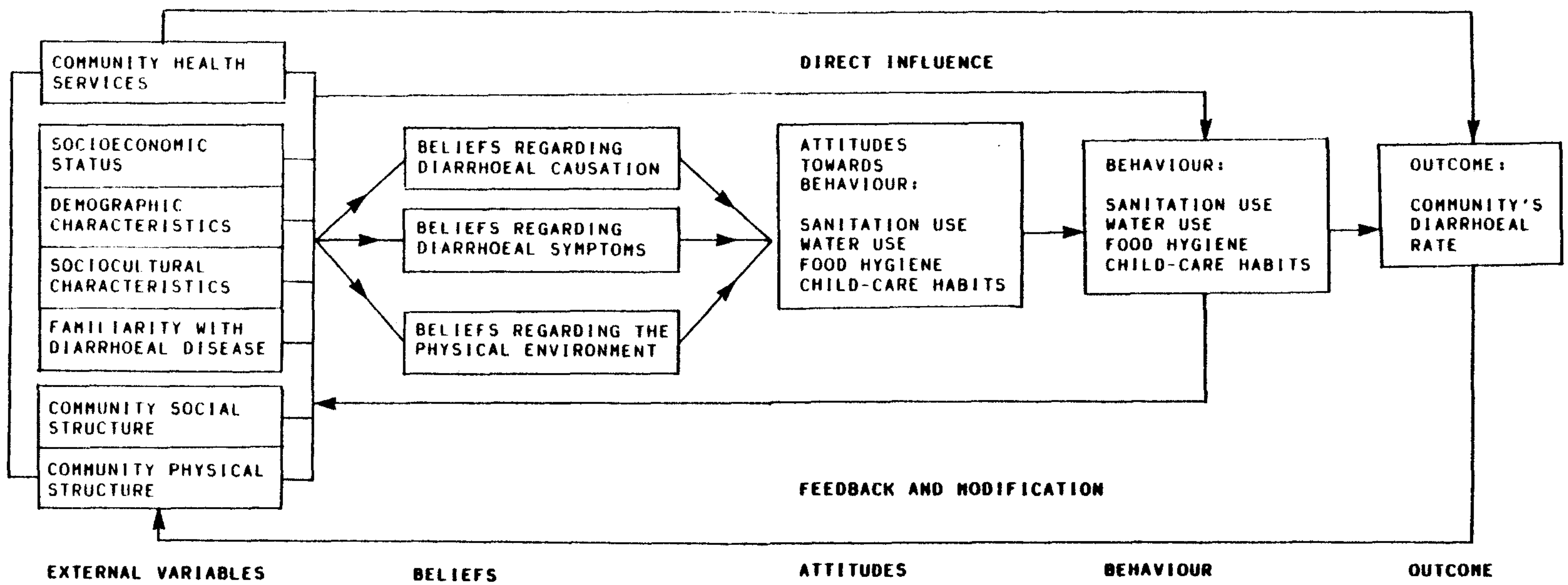
An abundance of energy and resources worldwide has been devoted to determining the sources of diarrhoeal infection and the utility and feasibility of different interventions. The transmission cycle involves a complex interaction of the biological, environmental, social, and behavioural determinants of diarrhoea (Taylor et al., 1985b). Previous studies examining the etiological aspects of diarrhoea have emphasized the relationship between biological agents (disease, host resistance) and environmental factors (housing and sanitation; water supply- focussing primarily on water quality).* However, as Myers (1982, p.17) notes, "disease is woven into the fabric of social life, therefore the distribution of disease, the ecological setting and behavioural patterns are culturally linked to an organised set of beliefs and attitudes with respect to diarrheal causation."*

This implies that the etiology of this disease, as with many others, can best be described using a socio-ecological model. Rather than postulating a single etiological cause, the model posits several determinants - environmental, social, and behavioural - which interact in a complex dynamic system, with diarrhoeal morbidity as the outcome. This model, originating from May's (1961) pioneering work in multiple-causation disease ecology, highlights the failings of single-variable etiological analysis in predicting diarrhoeal incidence. For instance, while biological agents, such as micro-organisms, or environmental factors, such as lack of public water and inadequate sanitary disposal units, are important causal determinants, a transmission cycle involving only one of these factors lacks the comprehensiveness to explain diarrhoeal causation and distribution patterns.

Domestic and ecological behavioural patterns - such as water and sanitation habits, food hygiene practices and child care management - determine the synergistic impact of environmental conditions, infective agents and host resistance. These overt activities are underlain by beliefs and attitudes regarding disease causality that originate from socio-cultural norms and value systems; and are constrained by contextual and situational factors which indirectly influence behaviour via beliefs, or directly affect behaviour (for a full review of the model, see Fishbein and Ajzen, 1975; 1980). Figure 2.1, modelling the behavioural-ecological etiology of diarrhoea, demonstrates

FIGURE 2.1

The Human Behaviour - Ecological Model of Diarrhoeal Disease Causation



Source: Myers, 1982

this. The extent to which external variables such as community health services influence a community's beliefs depends on their understanding of the community's health needs, their relationship with the community, the effectiveness of their services, and the type of health education they disseminate.

Personal characteristics, in particular income and education (and thus, knowledge of diarrhoeal infection), strongly influence beliefs and subsequently health status (Wilson, 1970). Demographic and sociocultural factors as well as familiarity with disease also play a role. For instance, a number of structural variables, such as knowledge of diarrhoea, prior experience with infection, traditional and western concepts concerning the transmission cycle, directly affect salient beliefs (Myers, 1982).

Community social and physical structure (political, medical, economic and social institutions; influential leaders and population composition) and cohesiveness have a significant impact not only on a community's beliefs towards diarrhoea, but also on some of the aforementioned external variables. In particular, "cultural dynamics" affect the perceptions of the community: "all known human groups develop some set of beliefs, cognitions, and perceptions consistent with their cultural matrices, for defining or cognizing disease (Wellin, 1977). For instance, if indigenous people define diarrhoeal disease differently - that is, they fail to recognise the important symptoms of infection - then it is likely that diarrhoeal rates will increase since no effective action will be taken to prevent infection.

Finally, diarrhoeal infection rates are the outcome of environmental quality and the level and types of services available in a community. Consistent evidence affirms that diarrhoeal incidence is highest where sanitation and water facilities are inadequate or unavailable. This makes epidemiological sense (see Tugwell et al., 1984): diarrhoeal pathogens proliferate in insanitary environments. Thus, the potential for increased interaction between man and microorganisms within the physical environment provided by water or sanitation facilities implies the potential for increased incidence of diarrhoea.

A model such as the above, suggesting that diarrhoeal determinants are amenable to behavioural manipulation, has important implications regarding the design and implementation of intervention strategies aimed at mortality reduction. In particular, health education emerges as a fundamental policy tool when the objective is to achieve critical behavioural changes. However, any such strategy must involve only minimal cultural and social disruption and must incorporate, or be sensitive to, local beliefs and values (Cutting, N.D.).

2.2 Diarrhoeal Determinants

The health-disease continuum is affected by a number of interacting sub-systems: ecological, political-economic, evolutionary, medical, physiological, climatic, nutritional, technological, energy, ideological, and cultural (Etlin et al., 1981). Therefore, the function of any individual element within this system is affected by the system as a whole, and the impact of a change at any point in the system, however remote, cannot be causally linked to a single constituent. A "caused" outcome is attributable to a number of preceding interactions which are linked in a non-linear fashion. In order to identify a single element to target for intervention , therefore, it is necessary to distinguish from among the interactions three types of causes; proximal, intermediate, and distal (White, 1986).

2.2.1 Biological Determinants

In terms of diarrhoeal etiology, the most proximal causes are micro-organisms. Currently, only two viruses, rota- and Norwalk virus, are recognised as medically important etiological agents of human gastroenteritis. Generally, this syndrome is self-limited, has an explosive onset, and is manifested by varying combinations of diarrhoea, nausea, vomiting, low-grade fever, abdominal cramps, headache, anorexia, myalgia, and malaise. Due to associated malabsorption, viral gastroenteritis may initiate or enhance the morbidity associated with malnutrition in marginally nourished populations. Dehydration occurs in forty to eighty-three percent of cases (Cukov and Blacklow, 1984). The highest incidence of rotavirus illness is found in patients six to twenty-four months of age, with the virus being responsible for about half of the hospitalized cases of acute diarrhoeal illness in this age group (Brandt et al., 1983).

The incidence of bacterial diarrhoea is uncertain, but it is estimated to account for thirty to fifty percent of diarrhoeal disease in children (Chen, 1984). It is most prevalent during the first five years of life, with a peak during the first two years (Nazer, 1982; Sharma et al., 1979). Most children afflicted suffer from acute episodes of diarrhoea, with or without fever or vomiting; the latter is a more frequent symptom of rotavirus (Rodriguez et al., 1977). Generally, enterotoxin-producing pathogens (such as V. cholerae and enterotoxigenic E. coli) produce acute profuse watery diarrhoea, while pathogens that invade and cause damage to the lining cells of the intestine (such as Salmonella spp. or entero-invasive E. coli) result in dysentery-like symptoms with small, viscous and bloody stools (Krugman and Katz, 1981). Again, the illness is usually self-limiting , with spontaneous recovery in several days provided lost fluids and electrolytes have been adequately replaced. The severity of the illness is usually related to water and electrolyte disturbances.

Despite the variability of clinical syndromes, differentiation of the causative organism is difficult, costly and time-consuming (Lam, 1985). Fortunately, the principles of treatment of acute diarrhoea, irrespective of the etiological agent, are the same: replacement of fluid and electrolytes by oral or intravenous routes. This has often led to the targeting of interventions which emphasize treatment rather than prevention. Advocates purport that such an approach is almost necessitated by the ubiquitous nature of the causal micro-organisms involved[1].

A number of intermediate "determinants" of diarrhoeal incidence can also be identified . No claim is made that these are **causes** of diarrhoea; rather, the evidence is

---

[1] However, while anti-diarrhoeal measures such as oral rehydration therapy (ORT) are acknowledged to be an effective intervention against mortality due to dehydration, they have a limited impact upon mortality caused by the more common chronic or dysenteric diarrhoeas. Also, ORT will have a minimal impact upon morbidity rates (Feachem et al., 1983).

sufficient only to denote them as markers or risk factors which may predict diarrhoeal disease (Taylor, 1986).

2.2.2 Environmental Determinants

Of the several factors that may reduce diarrhoeal morbidity and mortality rates, the improvement of water supply and sanitation investments have historically attracted particular interest. It has been intuitively believed that environmental modification through improved water supply and excreta disposal facilities, alone or as part of an intervention strategy, reduces disease transmission (Blum and Feachem, 1983). While many of a host of studies show an improvement in one or several health indicators (Esrey et al., 1985), a critical review of the evidence raises some doubts as to the validity of these results.

Rather than presenting a literature review of the results of the studies examined, this section will attempt to provide a critique of the methodological shortcomings common within the health impact literature in general, exemplified by these representative studies, which may invalidate the above conclusions. A methodological focus has been chosen in response to past tendencies to derive estimates of the impact of water supply or sanitation on disease by aggregating the findings of numerous studies, irrespective of serious methodological flaws.

Environmental interventions are inherently problematic to evaluate. Although convincing epidemiological evidence would at best stem from controlled trials where the intervention(s) is randomly allocated, interventions are usually introduced as a result of political, economic, humanitarian and other considerations. The ethical implications of the deliberate random allocation of aid for experimental purposes rather than by need will not be discussed herein as they are beyond the scope of this thesis.

A set of seven methodological problems that recur consistently within impact studies will be discussed (see Table 2.2 for summary[2]), with some observations drawn from the work of this author and colleagues.

Kumar et al.'s (1970) investigation of the impacts of excreta disposal on diarrhoeal morbidity in Indian children suffers from the absence of an external control sample. Without this, one cannot conclude with any certainty that the health benefits observed arose from differences in excreta disposal, rather than from changes in social, economic or other environmental factors. Control problems have arisen in other studies as well. Chandler (1954), for

---

[2] Table and methodological key adapted from the work of Blum and Feachem (1983).

instance, does include an external control, but the comparability of the control and intervention villages were not established prior to the introduction of sanitary improvements. Thus, the observed post-intervention differences in health cannot be ascribed to the intervention.

Several studies herein identify a frequent error in comparison. As is common practice, Henry (1981) and Chandler (1954) select a single control and an intervention community to compare. However, since the provision of water and sanitation supplies or health education is a community-wide activity, the sampling unit is the village rather than the individual or household. Therefore, the single village to village comparison effectively bases conclusions about the efficacy of treatment solely on the differential response between two **individuals** - one treated and the other not. Since the sample size is one for each category, no statistically valid conclusion can be drawn.

Inadequate control of confounding variables is a major problem in much of the literature on the impacts of environmental interventions (Blum and Feachem, 1983). As can be seen in Table 2.2, controlling for the innumerable variables that potentially influence the chosen health indicators is difficult; except perhaps in the improbable

TABLE 2.2

Selected Literature: The Impact of Improved Water Supply and Sanitation on Diarrhoeal Prevalence or Incidence. Methodological Problems.

Health Indicators	Type of Study	Environmental Variables or Interventions	Methodological Problems *	Reference
Diarrhoea/dysentery Prevalence	cross-sectional	Water supply, excreta disposal	c,d,e,f,g	Rahaman (1977)
Diarrhoea Incidence	longitudinal	Water supply, excreta disposal, housing, crowding, food	c,d,g	Moore (1966) Moore (1965)
Diarrhoea Incidence	longitudinal	Water supply, excreta disposal, flies	c,d,e,g	Gordan (1964)
Diarrhoea Incidence	intervention, longitudinal	Excreta disposal, health education	a,c,d	Kumar (1970)
Diarrhoea Prevalence, Nutritional Status	intervention, longitudinal	Water supply, excreta disposal	b,c	Henry (1981)
Diarrhoea Incidence	longitudinal	Water supply, excreta disposal, flies	c,d,g	Wolff (1969)
Diarrhoea Incidence	longitudinal, cross-sectional	Water supply, excreta disposal, crowding, flooding	none	Lye (1974)
Diarrhoea Incidence	cross-sectional	Water supply, excreta disposal, housing	c,d,e,g	Bertrand (1983)
Cholera Incidence	record review	Water supply	c,f	Khan (1981)
Parasite Prevalence	longitudinal (intervention village); X-sectional (control village)	Water supply, excreta + refuse disposal, health services	a,b,c	Chandler (1954)

*** Key to Methodological Problems:**

a. lack of adequate control
b. one to one comparison
c. confounding variable
d. health indicator recall
e. health indicator definition
f. failure to analyse by age
g. failure to record facility usage

context of a multi-village randomized intervention. Confounding variables may be dealt with in several different ways. Lye (1984), for instance, pre-selected sample villages based on comparability with respect to confounding variables, such as sanitation, health and nutrition programmes, and accessibility to public health training centres. A variation of this approach would be to control outstanding variables by analyzing and comparing matched sub-samples.

The most common measure of impact is diarrhoeal morbidity, particularly in young children. If this information is ascertained using interviews or surveys (see most incidence studies in Table 2.2), it is likely to be unreliable or incomplete. Research by the author on diarrhoeal incidence in Malaysia confirmed several explanations for this inadequacy. Firstly, it is possible that a single respondent will not be familiar with the diarrhoeal history of other family members. Even if known, there may be an unwillingness to divulge this information. Evidence suggests that illnesses involving social threat or shame are poorly reported (Mechanic et al., 1965). There is also a great deal of controversy surrounding the accuracy of recall periods: those exceeding forty-eight hours (such as those in five of the nine studies cited in Table 2.2) are considered to be methodologically problematic. One alternative to using a recall period is to rely on evidence of infection as an impact indicator, although as previously noted, the necessary facilities and expertise must be available.

Associated with diarrhoeal history deficiencies are problems of indicator definition. The interpretation of "diarrhoea", in particular, may vary among respondents if a definition applicable to that cultural context is not standardized. A number of studies (see, for instance, Rahaman et al., 1977; or Gordan et al., 1964) fail to define diarrhoea and thus appear to be measuring impact upon a vaguely defined illness. Measures of incidence and therefore intervention effectiveness would be much more valid if one uniform definition were to be used.

Rahaman et al. (1977) also neglect an age-specific approach, a failing that is particularly significant when investigating diarrhoeal incidence, or indeed any disease considered in an environmental impact study which is so unevenly distributed among various age groups. In addition, the impact of an intervention depends upon behaviour, and the usage of new facilities: both of these are age-dependent.

One shortcoming of a number of studies (Moore et al., 1965, 1966; Gordan et al., 1964a, 1964b; Wolff et al., 1969; and again, notably, Rahaman et al., 1977) having important behavioural implications for intervention strategies is the exclusion of observational - and often questionnaire - data on usage of new facilities. That is, the mistaken assumption is made that the presence of a particular water supply or sanitary facility is synonymous with usage of that facility. In the case of diarrhoeal studies, it is important to note the defecation behaviour in young children, those least likely to use the new facilities.

Several seminal studies aimed at prediction of diarrhoeal incidence through risk "markers" have made contributions to the understanding of the relationship between the environment and diarrhoeal occurrence. Bertrand and Walmus (1982) found that specific indicators of environmental sanitation (type of water services and faeces disposal, cleanliness of house) were associated with diarrhoea prevalence in young children. Their study, however, suffered from several shortcomings: the survey instrument focussed on perceived morbidity of other family members, and no control was made for confounding variables in the original analysis. A later correction of the latter problem, using logistic regression, did confirm a significant correlation, but the problem of recall bias remained. A similar investigation by Lye (1984), also with predictive purposes, suffered from none of the methodological problems proposed by Blum and Feachem (1983). In particular, an effort was made to carefully define diarrhoea, and relied only upon medically diagnosed infection as an indicator. An explicit effort was also made to control for important confounding variables, by adopting an age-specific approach and investigating facility usage through observation. Thus, there is little reason to doubt the validity of conclusions drawn in this paper. Lye's findings suggest that latrine type and water quality are significant **predictors** of diarrhoeal disease, but that the expected etiologic or impact fraction (the expected reduction in diarrhoeal cases) of changes in distribution of exposure to sanitation would only be achieved with corresponding changes in beliefs, and thus behaviour or usage, regarding sanitation practices. This is supported by Esprey et al. (1985) who suggest that it is possible for large-scale, well-designed projects combining water quality and supply, excreta disposal **and hygiene education** to achieve reductions in diarrhoeal morbidity rates of 35-50%. The median reduction attributed to such interventions when lacking an education component is 22%. Feachem (1984), while acknowledging a dependence upon certain pre-existing levels of water supply and sanitation infrastructure, cites evidence to suggest that hygiene education can, through resultant improved hygiene, reduce diarrhoea morbidity rates by 14-48%. Again, this has important implications for intervention strategies.

Azurin and Alvero (1974, p.26) suggest the importance of the interplay between sanitation, education, and hygienic behaviour in ameliorating cholera incidence in the Philippines:

> "the credit for the success... should also go to the population, whose collaboration and gradual acceptance of the new sanitation facilities and of the need for more hygienic habits led to a general improvement in environmental conditions. The study period was a time of considerable improvements in education and hygiene, largely through the efforts of the population itself, and therefore the achievements should be viewed as the product of community participation."

2.2.3 Behavioural Determinants

A discussion of the behavioural determinants of diarrhoeal disease naturally follows from the above. According to the socio-ecological model presented earlier in this paper, behaviour is the direct antecedent of the behavioural outcome, diarrhoeal incidence, and is affected by underlying attitudes and beliefs. The behavioural categories investigated herein include water and sanitation habits, hygiene practices and child care management.

One of the most pressing research needs is an explanation of the behavioural variables separating an intervention and an impact. To the extent that behavioural variables are true indicators of the use of specific preventive measures and hygienic practices, they are appropriate statistical predictors of infection risk or exposure. The studies examined, especially those of Lye (1984) and Azurin and Alvero (1974), demonstrate that although previous work suggesting a lack of association between health improvements and sanitation projects may have been pessimistic (Hughes, 1983), any associated mortality or morbidity reductions do not rise solely out of sanitation improvement, but rather out of sanitation practices.

An in-depth evaluation of evidence regarding the belief-behaviour link will not be undertaken in this thesis; rather, it will be accepted on the basis of its acknowledgement in behavioural studies. Instead, several of the relatively few studies which look at the relationship between these factors and diarrhoeal incidence will be discussed. Correlation between underlying beliefs and diarrhoea is essential, since it is these beliefs that must be changed to induce behavioural modifications.

To Bertrand and Walmus (1983), the demonstrated importance of waterborne pathogens in diarrhoeal disease (White <u>et al</u>., 1972; Feachem <u>et al</u>., 1977) suggests that individual knowledge, attitudes and practice with regard to household hygiene and the hygienic management of children are important factors in the transmission cycle.

Systematic research into this is sparse in the literature; this section considers several recent efforts to determine the role of the aforementioned factors in diarrhoeal transmission.

Although Bertrand and Walmus' study had methodological failings (see 'Environmental Determinants'), as a preliminary indicator it supports the supposition that attitudinal and behavioural factors are important in understanding and controlling diarrhoeal disease. After accounting for confounding variables, mothers' general knowledge of diarrhoea and its treatment, their perception of malnutrition, and sanitary state of home and children, were significantly associated with recent diarrhoeal episodes in children of the household. It appears that these factors operate through maternal practices, such as preventative measures, cleanliness, and hygiene habits to reduce the transmission of water-washed and waterborne diarrhoeal diseases. For instance, behavioural indicators such as infant feeding practices (breast feeding rather than bottle feeding), food preparation (such as boiling water), and household cleanliness (eating surfaces, water containers, toilet) have been strongly related to diarrhoeal incidence. Lack of knowledge and failure to apply effective therapeutic interventions have also tended to increase risk of infection (Taylor et al.,1985b).

Taylor _et al_.'s study employed self-reporting of diarrhoea episodes and nutritional status, and suffered some accessibility bias in its aggregate mortality and morbidity data. However, its results were duplicated by Lye's (1984) survey of rural Malaysian children, which was methodologically sound. Lye also found that religious beliefs were strong predictors of diarrhoeal disease through their influence on personal hygiene. Since in most developing countries there is a strong religious influence on culture (and vice versa) this again emphasizes the need to incorporate religion into intervention strategies.

Distal socio-economic determinants encompass those nearly universal factors which, in some form, affect all individuals. These include, for instance, political or economic systems - in a national or international context - which indirectly influence environment or behaviour, but whose impacts are immeasurable and not subject to change without a massive-scale intervention. Even discounting the notion that intervention strategies must involve minimal cultural and social disruption, an evaluation of the impact of these variables on diarrhoeal disease would clearly be beyond the scope of this paper.

Intermediate determinants of diarrhoeal disease include both direct and indirect measures of socio-economic status. A direct measure such as income, however, which should intuitively vary closely with morbidity but in itself does not strongly correlate with disease status, can be subdivided into a number of indicators whose impact can be more accurately measured.

Economic indicators are the strongest socio-demographic correlates of diarrhoeal morbidity, especially measures of material well-being. Those variables related to food preparation, consumption and diet (kitchen table, furniture, dish cabinet, purchased meat, garden plot) strongly predict disease incidence; those less direct, including number of children per household, mother's education, car ownership, housing tenure, and number of rooms in the house are statistically insignificant. While housing construction does not appear to impact upon incidence, the physical and hygienic conditions of the house are related to diarrhoeal episodes (Taylor et al.,1985b).

Relatively small differences in educational background may not directly influence diarrhoea transmission, but they probably influence maternal knowledge and practices relating to health and hygiene. The association between education and diarrhoea suggests that maternal knowledge, in conjunction with specific knowledge of the causes and treatment of diarrhoea, may have some protective value against diarrhoea in young children (Bertrand and Walmus, 1983).

2.2.4 Complicating Factor: Malnutrition

An examination of the literature suggests that the only factor significantly affecting the course of diarrhoeal disease is malnutrition and attendant dehydration. The synergistic relationship between infection and malnutrition has been well documented (Scrimshaw et al., 1968). That is, infection precipitates nutritional diseases in the malnourished, while malnutrition predisposes infants to infection and worsens the consequences of infection. Of particular importance here is that the severity and duration of diarrhoea increase with the degree of malnutrition (Morley, 1973; Gordan et al., 1964).

While many studies have sought to prove that increased diarrhoea is principally an outcome related to initial nutritional deficiency, the causal direction of the association is uncertain; nutritional status and diarrhoea are better understood as interacting and interrelated (Trowbridge et al., 1981). Some researchers claim that nutritional status is strongly predictive of the prevalence of diarrhoeal disease. Since prevalence is a function of the incidence and duration of episodes, Tomkins

(1981) investigated, and determined that both components were affected by malnutrition. Other evidence respecting incidence is inconsistent, however: some studies have found this relationship true only for three to five year old children, while other, repeated studies have found no relationship (Chen et al., 1981).

One of the most oft-cited examples evidencing the significant impact of malnutrition on duration of diarrhoeal episodes is a series of studies by Black and colleagues (1982a,c). These were an important contribution in terms of methodologic rigour, with detailed anthropometric measurement of nutritional status and the examination of etiology, incidence and duration of episodes. However, several deficiencies hinder the interpretation of the data. Data were presented for aggregate age groupings, children younger and older than twenty-four months. It is difficult to compare groups of children less than two years old which differ significantly in age, since nutritional status is marked by declines during the first two years of life, while frequency and duration of episodes of diarrhoeal diseases greatly increase. Black et al. also neglected to ensure environmental and socioeconomic comparability between groups. Trowbridge et al. (1981) argue that this failure could imply that diarrhoeal states may have been related more to environmental exposure or behavioural variables than to nutrition.

Despite the above shortcomings, these findings replicate those of a previous study in Bangladesh (Black et al., 1982b), and have since been replicated by many (see Nutrition Reviews, 1985; Black et al., 1984), which relate nutritional status (particularly wasting) to the duration of episodes of diarrhoea. A review of supplementary feeding programmes as an intervention strategy also concluded that little evidence exists that poor nutritional status predisposes to increased diarrhoeal disease incidence rates, but that there is strong evidence that it predisposes to increased severity and duration of episodes and to greater risk of diarrhoea-induced mortality (Feachem, 1983). A suggestion for future research in this area, which could aid in the identification of children at risk, would be to investigate the existence of threshold levels of malnutrition in the relationship.

The obvious implication of these studies is that, although improvement of nutritional status alone is not likely to reduce the high incidence of diarrhoea, nutritional interventions accompanied by other programmes aimed at reduction of occurrences could have a beneficial impact on the severity and duration of diarrhoea and its unfavourable nutritional consequences.

CHAPTER THREE

REGIONAL SETTING

3.1 The Study Area

Port Dickson lies on the southwest coast of Peninsular Malaysia, one hundred kilometres from the nation's capital of Kuala Lumpur (see Figure 3.1). The district has a population of 85,552, one-third of which is urban, concentrated mostly in the coastal town of Port Dickson. The rest is scattered throughout small kampongs or villages, and palm oil and rubber estates. The district is fairly representative of the Linggi River Basin, and the existing water and sanitation conditions are typical of much of semi-rural Malaysia.

Port Dickson was of particular interest to, and subsequently chosen for, this study due to its inclusion in the Linggi River Water Resource Management Project and to it being part of the pilot project area for the national water quality surveillance program.

As previously mentioned, it is one of three districts comprising the Linggi watershed, which has been targetted as the next major area of development in Peninsular Malaysia. In recent decades, the national government has

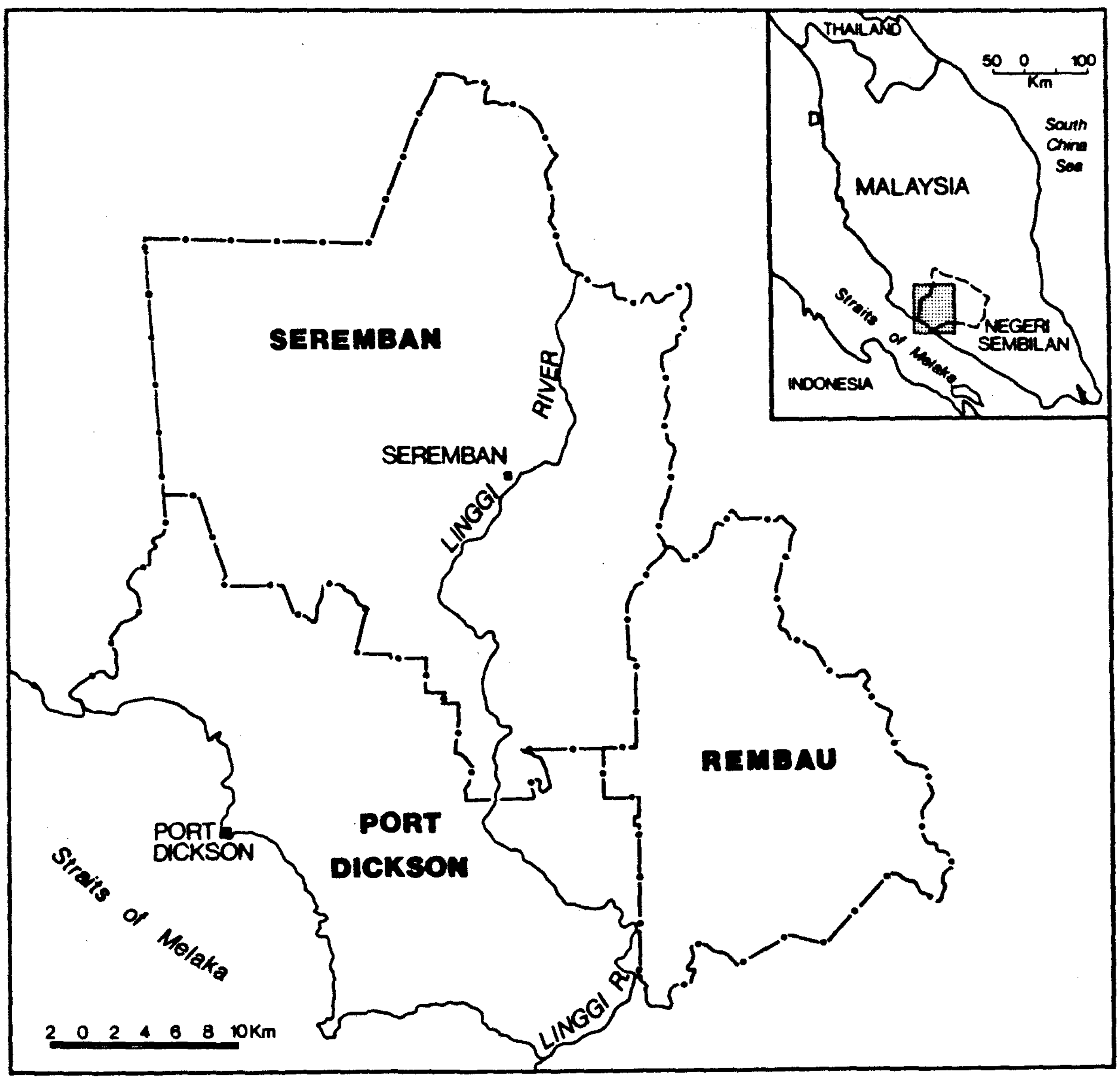


FIGURE 3.1

Malaysia and the Linggi River Basin

encouraged rapid urban and rural development. One consequence of this progress has been the overextension of many water supply systems due to the increasing demands from urban, industrial and agricultural activities. Port Dickson typifies a general lack of centralized sewerage treatment facilities. This, in addition to droughts and flooding, has resulted in heavy pollution and sewage contamination of waterways, and poses a threat to human health evidenced by the increasingly documented prevalence of waterborne diseases.

3.2 Public Health Status

Although general health conditions are superior to those of most other areas, Negri Sembilan has the highest incidence of water-related disease among the developed states, despite a similar level of economic development. However, data for Port Dickson seems to indicate that, with the exception of infectious hepatitis, rates of waterborne diseases are significantly lower in Port Dickson than in the state as a whole (Risyakaran et al., 1984). Infant mortality rates are also lower by half, placing Port Dickson in the same range as developed, industrialized countries. Infant mortality is considered to be an excellent indicator of the general level of sanitation since enteric disease is a common cause of death in very young children.

The Seremban sewerage master plan suggests that differences in illness burden among communities reflect the higher levels of public health resulting from the more extensive provision of water supplies, excreta disposal facilities and related infrastructures. However, it is still felt that "the threat of the catastrophic outbreak of a water-related disease...looms over...Port Dickson" (Government of Malaysia, 1982, p.1-3) due to untreated or improperly treated water, or as a result of deficiencies in wastewater disposal facilities.

3.3 Piped Water

Over ninety percent of the piped water supplied to Seremban and Port Dickson through an integrated regional system is provided by two Linggi River sources: the Pantai water treatment works (upstream, and serving Seremban); and the Sg Linggi plant (located **downstream** from the state capital of Seremban), providing much of Port Dickson's piped water. The Linggi plant makes Port Dickson and Seremban unique among major Malaysian towns in that they obtain the greater portion of their potable water supply from a source whose intake is located downstream, where discharges from domestic and industrial wastes tend to be highest.

The mean level of faecal coliform organisms (Escherichia coli) detected at this point in the Linggi River is almost forty times the World Health Organization's acceptable level for potable water supply. It is also estimated that the daily low flow at the intake contains ten percent by volume of untreated sewage (Linggi River Basin Project, Interim Report, 1985).

Samples collected at the Sg Linggi intake in 1980 and 1981 indicated concentrations of faecal coliform ranging from 35,000 to 350,000 MPN[1]/100 ml. Extremely high readings at other points in the Linggi and its tributaries have shown the water quality to be seriously degraded, with E. coli levels as high as 1,800,000/100 ml (Government of Malaysia, 1982). Such high bacteria measures are indicative of sewage-derived contamination and, more specifically, human and animal excreta.

These findings have profound implications from a public health perspective. Drinking water quality standards require that E. coli be absent in a 100 ml sample, and immediate investigations by health and waterworks authorities are mandatory if total coliform exceeds 20

---

[1] Estimation of bacteria is given in terms of most probable number per 100 ml (MPN/100 ml) when measured by the multiple-tube fermentation method (such as that used by the Petaling Jaya Chemistry Department), and colonies per 100 ml for the membrane filter method (used by this author).

MPN/100 ml or E. coli exceeds 2/100 ml (Ministry of Health, 1983c). The aforementioned bacterial and other contaminant concentrations (on average) exceed the proposed European Economic Community maximum levels in water sources where treatment is by the conventional processes used at the Sg Linggi plant (that is, screening, aerating, sedimentation, sludge tanks, filtration, and the addition of lime, alum and chlorine[2]). The World Health Organization recommends that conventional methods of treatment be used for raw water with a **total** coliform count of 50 to 5,000 MPN/100 ml (and, therefore, with a much smaller **faecal** coliform count). According to these standards, water from the Linggi falls into several classifications: 'heavily polluted', requiring extensive types of treatment; and 'very heavily polluted' - unacceptable unless special treatments designed for such water are used, and only to be used when unavoidable. Much of the Linggi potable source water is of the latter type.

3.4 Wellwater Quality and Sanitation

A preliminary bacteriological sampling and sanitary survey of village and estate wells was carried out in

---

[2] While dosing equipment is also in place for sodium silico-fluoride, a visit to the plant in August of 1985 revealed that the automatic doser had not been working for two years.

conjuction with this study, purely for informational purposes. Firstly, fifteen samples were taken from a range of sources: the majority were private supplies, with two Ministry of Health wells, and several estate wells and storage tanks. Using the MF method of coliform analysis and a Millipore faecal coliform field kit and incubator, faecal coliform counts were found to range from 0 to 1189/100 ml (see Appendix A).

It is interesting to note that both M.O.H.-supplied (but not necessarily monitored) wells had relatively high readings (506 and 779/100 ml); and that faecal coliform levels tended to be very high relative to total coliform. This usually implies that water requires fairly extensive treatment. The World Health Organization suggests that when more than forty percent of the number of coliform bacteria are found to be faecal, the water source should be considered to fall into the next higher category with respect to the treatment required. The readings from this preliminary sampling suggest that most of these sources should be receiving at least conventional - and possibly extensive - treatment, rather than the disinfection (chlorination) to which, at most, they are currently subject.

However, a sanitary survey of twenty-six non-M.O.H. wells revealed that nineteen were not chlorinated, nor was the water treated in any other way. For the seven that were chlorinated, the average treatment was a wholly ineffectual three times per year. Most of these wells served one or several families; a few, as many as one hundred people.

Two-thirds of the wells were subject to potential contamination due to their additional use for purposes other than drinking, such as bathing and washing clothes. Ten had liquid waste, animal or human faeces, or privies nearby. Only four wells had covers to deter animals, despite the fact that nearly half had animals living or grazing in close proximity to the water source. In one instance, the water hole for cattle was five feet away from the relatively unprotected water source (a hole in the ground) for several houses. Because many of these unprotected wells (fourteen are simply holes dug in the ground) are surrounded by bush, they are often contaminated by wild animals, especially monkeys.

Fortunately, given these less-than-satisfactory sanitary conditions, users of only four wells failed to boil their water. From among these four, however, only one well was chlorinated; and that only four times per year.

CHAPTER FOUR

DATA AND METHODOLOGY

4.1 Data Items and Data Collection

Data were derived from both primary and secondary sources. The burden of illness was measured by health services utilization, and incidence of notifiable infectious disease. Dated diarrhoeal records were kept of all cases reported to health professionals from estates, government clinics, and the district hospital from September 1 to December 31, 1985. Private clinics, which are not under government jurisdiction, refused to allow access to their records but did give a very general estimate of the number of cases seen. Information was collected on the age, sex, race and place of residence of affected individuals. Separately, the general category of water supply (Department of Water Supply [JBA] / treated; Ministry of Health wells; non-M.O.H. wells; pond or stream) was investigated for each of these individuals. Incidence data for notifiable infectious diseases were collected, with divisions again by age, sex, race, location and date of occurrence.

Unfortunately, utilization data is a biased measure of illness burden due to the effects of accessibility and willingness or ability to pay for health care. Utilization therefore may seriously underestimate the level of morbidity. In recognition of this, much of the research focussed on a household diarrhoeal morbidity survey which covered the population of the district of Port Dickson, approximately 85,500 people. The survey commenced December 6, 1985, and data collection was completed January 30, 1986, with the bulk of the surveys done by December 16, 1985. Only data collected during this period (thus excluding trial surveys) were used for this thesis.

The broad scope of information required necessitated the use of a household-based, interviewer-completed, structured questionnaire[1] (see Appendix A), which required the involvement of personnel familiar with health guidelines and fluent in several languages. Interviewers were chosen to eliminate possible biases in interview response that are common in cross-cultural research. To prevent linguistic and conceptual errors, it was insured that interviewers were from the same ethnic group and

---

[1] While some research in industrial countries suggests that self-assessment of an individual's health status is not appropriate for assessing incidence of specific diseases (see, for example, comments by Kroeger (1983)), in a recent review of methods for determining frequency of occurrence of infectious disease, house-to-house surveys were shown to be very reliable, and it was concluded that "carefully done surveys are a powerful tool for determining incidence and prevalence of various diseases" (Walsh, 1986, p.4).

similar social group as the respondents. The former were, as well, fluent in Malay, Tamil, and where required, one or more Chinese dialects. The use of local health personnel overcame many local taboos, and, since the interviewers were well-known to most community members and did not generate suspicion or hostility, interview answers were considered to be reliable. Familiarity with health standards meant that they required little training, apart from several supervised trial surveys.

Data were collected for 268 households (1,638 individuals), drawn from 14,403 households in the district. All individuals living within a particular household were surveyed, rather than just children, at the request of participating health officials: local Ministry of Health utilization records indicate that a large percentage of reported diarrhoeal cases are youths and adults.

The survey data (see Table 4.1) can be categorized as household demographic characteristics, morbidity indicators, and risk factors or risk markers. Morbidity outcomes were elicited by self-reporting of diarrhoea and associated symptoms for previous two-week and three-month periods. The self-reporting involved the use of a list of 'tracer conditions'; that is, the specific mention by the interviewer of possible disease outcomes (such as diarrhoea, blood- or mucus-tainted stools, vomiting or

TABLE 4.1

DIARRHOEAL MORBIDITY SURVEY VARIABLES

Variable Name	Description[2]	Survey Location
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS		
Race	Race	A1
NumPple	Number of people living in household	A1
KgPekLdg	Village, town or estate [kampong, pekan, ladang]	
MORBIDITY INDICATORS		
Diarrhea	Diarrhoea self-reported in previous two weeks or three months	B1+B2
Num_Events	(Average) no. of diarrhoeal episodes	B1+B2
Duration	(Average) duration of diarrhoea episode	B1+B2
Severity	Comorbidity and/or hospitalization	B1+B2
Recurrent	Chronicity; is diarrhoea recurrent?	B1+B2
Reported	Was this particular episode reported?	B1+B2
Gen_Report	Is diarrhoea usually reported?	B3
RISK FACTORS		
Child-Care Practices		
CareGive*	Child care-giver	A2
Breastfd*	Is infant breast- or bottle-fed?	C4

[2] For a detailed list of the categories used to code these variables for analysis, see Appendix C.

Water Supply

WatTreat	JBA; treated; untreated water supply	D7+D8
WatSupp	Drinking water source (piped, well, etc)	D9
Boil	Frequency of boiling water	D13+D15+D18
Shortage	Frequency of water shortage	D16

Sanitation

Toilet	Type of toilet facility	E19
Defecate	Indiscriminate defecation by individual household members	E21-E25
Flooding	Frequency of flooding	E26

Sanitation and Children's Hygiene (observed)

SanWater	Is the water source "sanitary"?[3]	F1-F3 + F6
YardCln	Is the yard free from faecal contamination and garbage?	F4+F5
KitchCln	Is the kitchen (especially food & water storage areas) clean?	D10+D11+F5+F12
SinkHse	Is there a sink in the house?	F7
SinkKit	Is there a sink in the kitchen?	F8
ChildCln*	Are the children clean?	F10
ChldPlay*	Do children play or sit in the dirt?	F11

* Where applicable

---

[3] Question F1: "sanitary" according to the guidelines of the Sanitary Survey Form-2 (Ministry of Health, 1983b, pp. 37-40).

fever). The responses were indicative of severity and chronicity of morbidity. The standardization provided by the use of an appropriate list of such conditions has been shown to result in more accurate measures of ill health perception, since it may suppress individual and collective semantic and conceptual variation in the perception and description of symptoms (Kroeger, 1983; Woolsey et al., 1962; Belcher et al., 1976). In conjunction with this, since, as has been stated previously in this thesis, the interpretation of 'diarrhoea' may also vary among respondents, a standardized and culturally operationalised definition was incorporated into the questionnaire (see Appendix A).

Interviews were conducted in family or household groups in an attempt to eliminate error through proxy reporting, which has been shown to be problematic in studies concerned with accurate measures of disease prevalence (Kosa et al., 1967).

In an attempt to determine the magnitude of under-reporting and provide a more accurate, albeit short-term, estimate of diarrhoeal morbidity, the respondents were asked whether or not each episode had been reported to a health practitioner, and if, generally, it was a household practice to visit a doctor or hospital when one suffered from diarrhoea.

Data were collected on risk factors in discrete categories under four general headings; information under the first three (child-care practices; water supply; and sanitation) was provided by the respondent, while the fourth (sanitation and children's hygiene) required structured observations by the interviewer. The questionnaire design included cross-checks[4] on sensitive issues to ensure the reliability of responses.

4.2 Survey Sample Design

Port Dickson district was initially stratified into towns, kampongs (villages), and estates. Detailed residential maps designed for a malaria eradication programme enabled an accurate delimitation of 301 clusters, each containing approximately fifty households[5]. A two-stage cluster sampling was performed, wherein fifty-five clusters were selected at random, with the percentage of total clusters selected in each of the three strata (town, kampong and estate) in accordance with the percentage of

---

[4] For example, if a respondent indicated that he or she "always" boils all household water, this would be cross-checked against responses on questions regarding the boiling of water that is to be refrigerated, and the availability of fuel for cooking.

[5] To avoid external or confounding variables (such as race or lifestyle differences), several cluster sizes were allowed to vary slightly when conforming to estate, town, or kampong boundaries. Minimum cluster size was forty households, maximum size was fifty-six.

the total number of households in each of the strata subpopulations (that is, 13%, 54% and 33% respectively). This cluster sample size was larger than the least number of clusters required in order to compensate for a reduction in total sample units to accommodate available survey resources.

From each of the fifty-five clusters, eight units (households numbered or tagged during malarial spraying) were randomly chosen. Interviewers were instructed to begin interviewing at the first unit listed, and to continue until having successfully interviewed five units. This provided for the replacement of unavailable households by other randomly chosen study units.

One cluster was excluded from the study due to lack of cooperation from the population and inconsistent and often deliberately misleading information given in household surveys[6]. In accordance with study replacement guidelines (Lutz, 1982), this cluster was not replaced.

---

6 The individuals within this kampong on the urban fringe of Port Dickson were pig farmers who had a history of conflict with local authorities regarding the contamination of water supplies, and had been subject to various efforts to displace them. They were, perhaps justifiably, reticent with health personnel questioning them about water supply and water-related diseases.

4.3 Data Limitations

Interpretation of the data presented in this thesis must, of course, take into account any limitations of the methods used in their derivation. Several potential weaknesses of the survey were ones of lack of independent validation of measures used. A limited number of others refer directly to questionnaire design.

Firstly, the survey incorporated no anthropometric measures (physical and/or biochemical examinations) to determine nutrition and other health statuses; hence, there was no validation of diarrhoeal self-reporting. However, previous studies have found a limited degree of correspondence between health interviews and validating examinations, particularly for diarrhoea. It has been suggested that, for diseases such as these where the severity or chronicity is of greater consequence than merely determining presence of infection, the afflicted individual's perception of the disease may be more relevant than the physician's prevalence figures (see, for instance, Belcher et al., 1976).

In conjunction with the above, no cross-check was performed between survey-determined prevalence and health service utilization. Again, varying degrees of discrepancy have been shown to exist between health interview data and hospital and physician records (Belloc, 1954; Simmons and

Bryant, 1962). In this particular study, there were sufficient shortcomings in utilization data to rule out attempts to achieve interview and record correspondence: private physicians refused to allow access to confidential patient files, and to keep separate records of diarrhoeal diagnoses for the study period; many people suffering from diarrhoea do not seek medical attention (although they may instead receive traditional treatment), necessitating a much larger sample than resources would permit; patients also seek treatment at clinics and hospitals in neighbouring districts or in the nearby state capital of Seremban; and there is incentive for some estates to deliberately underreport water-related disease[7].

Survey measures of hygienic quality of the water were not validated by microbiological testing. Ministry of Health (MOH) and Department of Water Supply (JBA) bacteriological sampling reports, analyzing faecal coliform

---

[7] Sua Grensing Estate, for example, reported only one diarrhoeal case (listed as food poisoning) for the previous eleven-month period, despite the fact that numerous clearly water-linked outbreaks and water treatment violations had been identified by the Health Inspector in the recent past. This form of underreporting is usually occasioned by the fear of reprisals from the labour ministry, the only government agency with the power to enforce recommendations regarding water treatment and storage, health and safety for estate workers made by the ministry of health. It is interesting to note that the diarrhoeal records were returned (with reluctance) to the study team by the estate manager, rather than by the hospital assistant who compiles the records.

counts (Escherichia coli), and chlorine residual, among other parameters, were gathered for a twenty-month period, including the study period. These data were available for all water sampling stations within the district, theoretically enabling a comparison of some form of temporal index of quality derived from government records, and survey indices for users reporting JBA water supplies. However, no comparable records existed for non-JBA users, a significant proportion of the population. Simple logistics, combined with state government hesitation to allow comprehensive sampling of these water supplies, suggested that this component of the survey validation be removed. Furthermore, it was determined that the chemistry department measures of E. Coli and chlorine residual were grossly inaccurate due to both improper sampling and storage procedures, and faulty lab testing[8]. As well, even

---

8 A confidential progress report highly critical of the National Drinking Water Quality Surveillance Program (Rembau/Tampin District) cited a number of weaknesses in water sampling and storage procedures (Teng, 1986). Sampling bottles from the chemistry department are received or stored in insanitary conditions and often damaged. Chemical stocks for testing total residual and free residual (active) chlorine are limited: swimming pool test kits - not known for their accuracy - are frequent substitutes. Despite strict guidelines for storage and shipping (samples must be packed in ice, stored in a dark environment at a constant temperature, and tested within 24 hours (Ministry of Health, 1983b;c)), samples are often exposed to rain, heat and sun; and sometimes subject to shipping delays of several days.

Random cross-checks of water supplies (conducted in conjunction with this study) using the MF method of a verified absence of E. Coli does not rule out the possibility of pathogenic coliforms persisting in the water. E. Coli is a reliable indicator of faecal pollution only in temperate climates (Evison and Jones, 1973); it is inadequate in tropical climates, where higher temperatures rapidly accelerate the death of the bacterium (Thomson, 1981). Therefore, the lack of microbiological confirmation of questionnaire data does not invalidate that part of the study.

As mentioned in the literature review, it must be acknowledged that reliability of respondents' period of recall is questionable in survey design. While some studies have shown that underreporting of minor complaints can occur within a one- or two-week period[9], Freij and Wall (1977) found that in a two-week recall period overreporting (due to overestimation of recent illness) and

---

coliform analysis and a Millipore faecal coliform field kit and incubator found water supplies that had consistently been recorded as having no contamination in actuality containing hundreds of E. Coli per 100 ml. Government, estate, and private water supplies, and Ministry of Health wells sampled ranged from a low of 0 E. Coli per 500 ml (in a few cases) to a high of 5945 E. Coli per 500 ml. Also, two samples taken from the same well at the same time under excellent environmental conditions yielded E. Coli measures several hundred counts apart when tested by the chemistry department in Petaling Jaya (the centre for the country's water quality testing).

[9] with underreporting being inversely related to the severity or duration of the affliction, and directly related to the interval between episode occurrence and interview date.

underreporting (of forgotten earlier events) largely cancelled out. A three-month recall period is suspect, but is a compromise between obtaining adequate information and loss of accuracy due to unreliable recall concerning relatively mild episodes.

A problem with gathering survey data at the household level is that it is not possible to distinguish among primary, secondary, tertiary, etcetera infections at the individual level. Therefore, the measure of morbidity utilized for this study was the household's most severe diarrhoeal case or the individual with the highest number of episodes.

4.4 Data Manipulation and Analysis

Data from both the diarrhoeal incidence records and the household morbidity survey were separated into two or more mutually exclusive, nominal categories for each variable. Discrete numerical values were arbitrarily assigned to the various categories, with the exception of age (which allowed for fractions of years) in the incidence data. These codes were stored using DBase III, a database management package, and Minitab, a general purpose statistical computing system.

The levels of analysis varied among the data sets. Incidence data were evaluated at the personal level, as were survey variables related to non-reporting of specific episodes, and diarrhoeal-associated morbidity factors. From these could be derived a descriptive analysis using DBase III. General underreporting and diarrhoeal risk factors were measured at the household level. The significance or association of these risk markers with self-reported diarrhoea was determined using a chi-square test in Minitab.

A chi-square test enables one to interrelate nominal scales with any number of categories. It is a very general test that can determine whether or not frequencies which have been obtained empirically differ significantly from those which would be expected under a certain set of theoretical assumptions; or, as it is used in this thesis, whether or not the distribution of frequencies from one sample differs significantly from the distribution of one or more others. In other words, it is a test for association (or significant differences) among a number of independent, random samples. Each sample consists of absolute frequency data (not percentages) and is divided into mutually exclusive categories. Individual categories must meet the assumptions required to perform the chi-square test: that is, no category with an expected frequency of less than one, and not more than one category in five with an expected frequency of less than five.

The chi-square measure calculates the difference between observed and expected frequencies or cases: the larger the discrepancy, the larger the value of chi-square. The critical region is in the upper tail of the distribution, since the concern is whether or not the derived chi-square value is larger than would be expected by chance (and the difference, therefore, is significant).

In this study, three levels of significance (denoted by α) were applied to the chi-square values, creating four categories of relationships: highly significant (α =.001), significant (α = .01), slightly significant (α = .05) and non-significant (α < .05).

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Diarrhoeal Incidence

In total 1,017 cases of diarrhoeal and infectious (diarrhoeal) disease were reported between September 1 and December 31, 1985. This is likely an underestimation of the burden of illness since district hospital and clinic records do not contain information about local people seeking medical treatment outside of the district, while patients listing addresses from other regions were excluded from the study. Also, these records indicate incidence, not prevalence. That is, they do not account for duration; nor do they identify cases of multiple / recurring episodes.

Estates accounted for forty-seven percent of all cases (despite their representing less than one-third of the households within the population), while Port Dickson Hospital contributed thirty-three percent, government clinics nineteen percent, and the Ministry of Health (record of notifiable infectious diseases) less than one-half of one percent. The distribution of diarrhoea by race can be found in Table 5.1.

TABLE 5.1

Diarrhoeal Incidence and Percentage of Underreporting by Race

RACE	Diarrhoeal Incidence	Percentage of Underreporting	Revised Incidence
Chinese	159	15	183
Indian	557	31	730
Malay	293	12	328
Other	8	38[1]	11
Total	1017		1252

With this distribution, and survey results on underreporting, it is possible to estimate the number of undocumented episodes within the district. Given the significant variation of propensity to seek medical treatment among races, separate measures of underreporting have been determined for each race. The revised figure for diarrhoeal cases within the district is 1,252, an increase (or rate of underreporting) of nineteen percent. This clearly contradicts the Government of Malaysia's (1982) estimate, which suggests that water-related infectious diseases are underreported by as much as a factor of twenty.

As mentioned previously, these data do not include

[1] This percentage may not be exact since the category of "other" on the survey from which this value is derived was defined as "other native" such as Orang Asli or Dayak. This same category for the incidence data included several non-natives.

cases seen by private practitioners. However, the Chief Health Inspector (Dionysius, 1986) estimated the total diarrhoeal caseload of the thirteen private clinics in Port Dickson to be twenty per day. This implies that diarrhoeal incidence within the district was approximately 3,457 within this particular four-month period. Assuming that there is not a great deal of variation over time, this would suggest a minimum preliminary estimate of annual incidence of twelve percent. This confirm Lo's (N.D.) assertion that the official average of thirteen per thousand yearly is greatly underestimated. Corroboration is also found in the results of the household morbidity survey. Of 1,638 individuals, 65 diarrhoeal episodes were self-reported for a three-month period. This translates to an annual incidence of sixteen percent.

5.2 Determinants of Underreporting

Within the diarrhoeal morbidity survey, four factors were considered to be potential determinants of underreporting: number, duration, severity and chronicity of events. Surprisingly, the average number of diarrhoeal episodes did not seem to be related to reporting. While multiple episodes of one to three events consistently generated a two-thirds reporting rate, episodes of four to six events (of which there were a limited number) demonstrated no clear pattern.

The expected relationships emerged, however, with the three remaining variables. When the duration of episodes was greater than seven days, reporting increased from sixty-five to one hundred percent. While in cases of mild diarrhoea - that is, those exhibiting no comorbidity - only eleven percent sought treatment from a doctor or hospital, the rate of reporting increased to eighty-eight and ninety percent for severe and very severe cases respectively. And in cases where the episode was one in a history of chronic diarrhoeal events, reporting was fifteen percent above that for nonrecurrent events. Chronicity, therefore, appears to promote reporting, as do increased duration and severity of episodes.

Of the three, it is likely that severity plays the greatest role. Almost three-quarters of all cases were recorded as severe (39%) or very severe (33%). Only thirty-seven percent experienced multiple episodes of diarrhoea: sixty-three percent reported only one event, and ninety-one percent had three events or less. Recurrent episodes and those of long duration (greater than one week) were both less common (16% and 10% respectively).

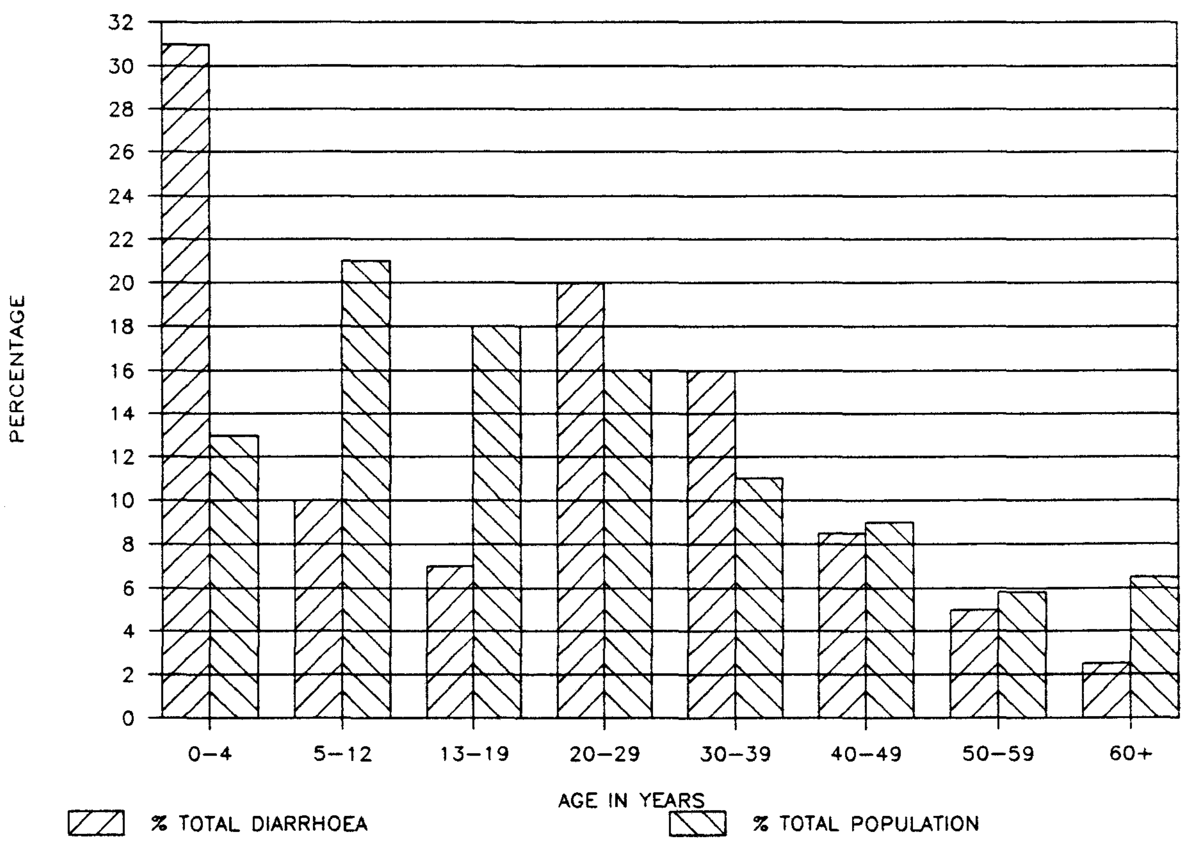
5.3 Diarrhoeal Population Profile

From the incidence data, one can derive a limited profile of the population reporting episodes of diarrhoeal disease. The average age for both sexes was 20.8 years, and had little variation among races. However, a graph of incidence by age (see Figure 5.1) provides several noteworthy facts.

FIGURE 5.1

Distribution of Diarrhoeal Incidence by Age and Distribution of Population by Age

Port Dickson District



Firstly, as would be expected, very young children (0-4 years) account for by far the highest percentage of episodes, despite representing only a small fraction of the population. More surprising is the fact that those over sixty years of age account for a disproportionately small percentage of diarrhoea within the population, despite their reputedly having high susceptibility to diarrhoeal disease. This could be explained by a disinclination among the elderly - to whom frequent bouts may be customary - to seek treatment, or by a reliance upon traditional medicine. However, a lower-than-expected incidence rate among the aged was also found in the household morbidity survey (which accounted for non-reporting), suggesting that this is a true rate. This may also support claims made by many of those interviewed, who believe that they have developed a form of "immunity" to diarrhoeal disease through a lengthy association with diarrhoea and untreated, unboiled water[2].

Lastly, an interesting reversal occurs between late childhood/youth and young adulthood. Those aged five to nineteen years have a percentage of diarrhoea that is less than half of their share of the population, while those

---

2 The existence of such a phenomenon would be unusual, as recurrent diarrhoea is more commonly recognized for its debilitating influence, resulting in a predisposition towards further disease.

from twenty to thirty-nine exhibit rates that are twenty to thirty percent higher than their population share. Perhaps this exemplifies the effects of secondary transmission; that is, that parents of young children are likely to experience higher rates of diarrhoea resulting from frequent physical contact with infected children. Five- to nineteen-year-olds attend school on a regular basis, and thus have little interaction with younger siblings. They are also at an age where they understand and comply with basic health precautions, such as washing hands and drinking boiled or treated water.

The distribution of diarrhoeal incidence by age within each race (see Table 5.2) suggests some interesting variations among ethnic groups. Although the pattern of disproportionately high rates of diarrhoea in very young children and low rates in the elderly is repeated throughout, there are several anomalies within other age groups. The Chinese, in particular, can be seen to differ from the overall pattern seen earlier. They account for a relatively high percentage of diarrhoea at an early age (5-12 years), equal to their share of the population, while exhibiting an unusually low rate between the ages of twenty and thirty-nine, as compared to the Indians and Malays.

What is interesting in light of the above is a comparison of diarrhoeal distribution among all races, as

TABLE 5.2

Percentage Distribution of Diarrhoeal Incidence and Population by Age per Race

AGE (years)	CHINESE % of diarr	CHINESE % of popn	INDIAN % of diarr	INDIAN % of popn	MALAY % of diarr	MALAY % of popn
0-4	31	12	27	14	38	14
5-12	22	22	10	21	4	21
13-19	7.5	17	8.4	17.5	3	19
20-39	19	27	38	29	41	25
40-59	14	14	14	13.5	13	15
60+	5.6	8	2.3	5	1.4	6

TABLE 5.3

Percentage Distribution of Diarrhoeal Incidence and Total Population[3] by Race

Male and Female

RACE	MALE % of total diarr	MALE % of total popn	FEMALE % of total diarr	FEMALE % of total popn	TOTAL % of total diarr	TOTAL % of total popn
Chinese	10	18	6	18	16	36
Indian	31	8.5	24	8.3	55	17
Malay	18	23	11	24	29	47
Total	59	49.5	41	50.3	100	100

[3] Population distribution statistics are those for the state of Negri Sembilan and are assumed to be representative of Port Dickson district (for which comparable figures are unavailable).

in Table 5.3. Both the Chinese and Malays have a proportion of diarrhoea that is equal to roughly half of their share of the population (which is eighty-three percent in total), and together account for only forty-five percent of all incidence within the district. Indians, who represent only seventeen percent of the population, are responsible for **fifty-five percent** of all diarrhoeal illness. Males of all races account for slightly more diarrhoea than females (in sum, 59% as opposed to 41%), despite having a population composition that is strikingly similar (both equal to fifty percent in total).

One possible explanation for the extraordinarily high overall rate of diarrhoea among Indians can be found in Table 5.4. Although the population supplied by JBA and pond or stream water was found to be equal (48% and 46% respectively, with 3.4% of supplies unknown, and wells accounting for less than three percent) the distribution among races was not. Both the Chinese and Malays derive three-quarters of their water from Department of Water Supply pipes, while less than one-third of the Indians are supplied by the JBA. In contrast, most of their water (69%) comes from ponds or streams. This seems to suggest that the water supply may be at fault in the transmission of diarrhoeal disease. This and other factors will be examined in the next section in an attempt to isolate risk markers or predictors of diarrhoea.

TABLE 5.4

Percentage Distribution of Water Supply by Race

WATER SUPPLY	RACE		
	Chinese	Indian	Malay
1. JBA	72	29	76
2. M.O.H. wells	0	0	.4
3. non-M.O.H. wells	4	2	3
4. pond or stream	24	69	20

5.4 Diarrhoeal Risk Markers

Of the nineteen variables tested for association with diarrhoea (see Tables 5.5 and 5.6; Appendix D), eleven proved to be significantly related ($\alpha \geq .05$). Of those, six were highly significant. Surprisingly, the latter were a mixture of behavioural and sanitation variables; water supply / treatment had only a .01 significance level.

As was expected from the outset, diarrhoeal rates were shown to vary with frequency of boiling water. Only twelve percent of the survey population who claimed to always boil their water had had recent episodes of diarrhoea. Little variation was found in rates among those who frequently or sometimes boil, and those who never do (46% versus 50% respectively), suggesting that it is not the frequency of

TABLE 5.5

Levels of Significance: Diarrhoeal Risk Markers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. NumPple		NS			**NS**															
2. Race	NS		NS	HS	**HS**		HS	HS	HS		HS	NS		HS	NS	HS	S	SS	HS	NS
3. CareGive		NS		NS	**NS**	NS													NS	NS
4. KgPekLdg		HS	NS		**NS**		HS	S	HS	HS	HS		HS				HS	HS		
5. Diarrhea	**NS**	**HS**	**NS**	**NS**		**NS**	**S**	**S**	**HS**	**NS**	**HS**	**NS**	**NS**	**HS**	**S**	**HS**	**SS**	**SS**	**HS**	**NS**
6. Breastfd			NS		**NS**															
7. WatTreat		HS		HS	**S**			HS	NS					HS						
8. WatSupp		HS		S	**S**		HS		NS											
9. Boil		HS		HS	**HS**		NS	NS						HS						
10. Shortage				HS	**NS**															
11. Toilet		HS		HS	**HS**															
12. Defecate		NS			**NS**															SS
13. Flooding				HS	**NS**															
14. SanWater		HS			**HS**		HS		HS											
15. YardCln		NS			**S**															
16. KitchCln		HS			**HS**															
17. SinkHse		S		HS	**SS**															
18. SinkKit		SS		HS	**SS**															
19. ChildCln		HS	NS		**HS**															
20. ChldPlay		NS	NS		**NS**							SS								

Level of Significance:			
	α = .001	Highly Significant	[HS]
	α = .01	Significant	[S]
	α = .05	Slightly Significant	[SS]
	α < .05	Non-Significant	[NS]

boiling water per se that is responsible for diarrhoeal transmission, but rather the ingestion of unboiled water in any amount.

TABLE 5.6

Level of Association or Significance of Risk Factors with Self-Reported Diarrhoea

Highly Significant (α = .001)	Significant (α = .01)	Slightly Significant (α = .05)	Non-Significant (α < .05)
Race	WatTreat	SinkHse	NumPple
Boil	WatSupp	SinkKit	KgPekLdg
Toilet	YardCln		CareGive
SanWater			Breastfd
KitchCln			Shortage
ChildCln			Defecate
			Flooding
			ChldPlay

Hygiene habits also appear to play an important role. Cleanliness of the kitchen was associated with diarrhoeal rates that were two-thirds of those where water and food storage areas were unclean. Similar proportions of morbidity were found when comparing clean yards with those contaminated by faeces and garbage (α = .01). And children who were observed by Ministry of Health personnel to be slightly or very unclean had twice the incidence of illness of children found to be very clean.

Sanitation factors proved to be equally important.

Water sources free from exposure to potential contaminants (such as garbage, excrement, and non-consumptive usage) were associated with levels of morbidity which were two-fifths of those of sources considered to be insanitary. The relationship between diarrhoea and types of toilet facilities held some surprises. As one might logically suspect, households with private flush toilets had the lowest rate of incidence (18%). The next lowest rate (21%) was for those who had no toilet facilities or used a bucket. Although this result was entirely unexpected, it perhaps explains the lack of significance between diarrhoea and indiscriminate defecation.

A second surprising element was that users of private pit latrines, versus those of shared pit latrines or septic tanks, had almost identical rates of diarrhoea (43% and 44%). The rate for the latter may, however, be deceptively low due to the inclusion of the shared flush toilets. The only clear conclusion one can draw, then, is that private flush toilets as compared to pit latrines are associated with substantially lower rates of diarrhoea.

Probably the most interesting, and controversial, result in terms of the conclusions that might be drawn from it is the high level of significance between diarrhoea and ethnicity. This is not surprising, given the findings of the incidence study. Table 5.7 shows the distribution of survey diarrhoeal incidence among the various racial groups. It can be seen that these percentages are comparable to the same distribution among the incidence study population subgroups (see Table 5.3 for comparison)[4]. This, however, does not take into account the fraction of the total population which each subgroup represents. A more revealing figure, therefore, is the rate of diarrhoea for each race.

TABLE 5.7

Percentage Distribution of Diarrhoeal Incidence and Survey Population by Race; Percentage of Race with Diarrhoea

Household Diarrhoeal Morbidity Survey

RACE	% of Survey Diarrhoea	% of Survey Population	% of Race with Diarrhoea
Chinese	14	19	19
Indian	57	35	40
Malay	12	38	8
Other Native	17	8	50

Again confirming previous findings, Indians were discovered to have a much higher diarrhoeal rate than

[4] Table 5.3 excludes the category "other" since it accounted for only a fraction of a percent of total diarrhoea. "Other natives" were yet a fraction of that. The non-representation of natives in records of documented diarrhoeal illness can likely be attributed to their relatively high rate of underreporting and to their low share of the population.

either Chinese or Malays. However, other natives, especially the Orang Asli, had the highest by far. That this fact was not in evidence during the incidence study was probably due to the small fraction of the population which they represent and to their high rates of non-reporting.

The existence of a strong relationship between race and diarrhoea is indisputable. However, as noted previously, it is not necessarily a causal relationship. Clearly, one's ethnicity does not predispose one to certain levels of diarrhoea. It is therefore necessary to explore the underlying factors which could lead to these results. There are a number of personal and community characteristics and behavioural categories which have a highly significant relationship with race. It is likely, then, that it is any of a number of these infrastructural and behavioural factors which strongly influence diarrhoeal rates among different ethnic groups.

Household and environmental physical conditions were found to relate strongly with race (α = .001) and diarrhoea. The Orang Asli ("other natives"), who had the highest diarrhoeal rates among the populace, differed significantly from the three other ethnic groups in terms of their water sources. While the bulk of the supply of the latter groups was JBA (63-91%) piped into the house

(75-82%), and sanitary (78-92%), native supplies were for the most part untreated non-JBA wells, rivers or ponds (68%), seventy-one percent of which were classified by the Ministry of Health as insanitary.

This has clear implications for diarrhoeal transmission. Both water treatment and supply have been shown to be significantly related to diarrhoea. In particular, non-JBA untreated water has an incidence rate twice that of both JBA and non-JBA treated water. Similarly, supplies piped into the yard or house are associated with one-third to one-half of the morbidity level of well or river (etcetera) water.

A slightly different situation was found with toilet facilities. While the majority of the households in the same three groups had private flush toilets, a large number of the Chinese also had none (33%), while many of the Indians (28%) shared facilities. Fifty percent of native homes had private pit latrines. This would also help to explain the high percentage of diarrhoeal incidence among Indians and natives, since earlier it was determined that households having private or shared pit latrines had significantly higher rates of diarrhoea than those with flush toilets and those with none.

Diarrhoeal rates have also been found to be slightly related to the existence and location of sinks in the home.

Households with sinks had rates that were twelve percent lower than those without. Sixty-three percent of Indian homes had no sink, while more than half of those of the other three groups did. Of existing sinks, seventy-seven to one hundred percent (depending upon race) were located in the kitchen, with the exception of those in Orang Asli kampongs, where less than half of household sinks were in the kitchen. The fact that many Indian and native families tend not to have ready access to a kitchen sink again suggests a partial explanation for their greater levels of diarrhoeal incidence.

Behavioural patterns regarding hygiene and child-care were also found to strongly influence diarrhoea, and to vary among ethnic groups. It is likely that water hygiene practices are affected by sociocultural characteristics, particularly religion, but this hypothesis was not explicitly tested.

Malays have relatively high frequencies of boiling water (83% 'always' boil) despite having the greatest percentage (92%) of sanitary sources. Chinese have similar (but lower) statistics. Both the Indians and the Orang Asli, however, have low frequencies of 'always' boiling (45% and 55% respectively; the latter despite having the highest occurrence - 71% - of insanitary supplies), and, while the other three groups have at most 4% of households that never boil water, 26% of Indian families do not ever boil their water.

Kitchen sanitary conditions and child hygiene - both highly related to diarrhoea - were also better in Chinese and in Malay households. For instance, while seventy percent of Malay children were judged to be very clean, seventy percent of Indian children (and sixty-two percent of native children) were found to be unclean. Similarly, twenty percent of Indian and twenty-nine percent of Orang Asli households were found to have unclean or insanitary kitchens, while Malays and Chinese had one and six percent respectively.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

This thesis has examined diarrhoeal disease and its associated morbidity risk factors in the district of Port Dickson, Malaysia. It has achieved four objectives. Firstly, an attempt has been made to provide an accurate measure of burden of diarrhoeal illness within the district through the use of health services utilization records and the incorporation of survey-derived measures of underreporting. Secondly, four morbidity-related variables have been examined in order to determine the factors influencing the decision to seek medical treatment, and therefore, underreporting. A brief profile of the diarrhoeal-affected population was then derived using incidence data. Lastly, nineteen risk factors or markers were evaluated for their association with self-reported diarrhoea.

Burden of diarrhoeal illness within the district has been estimated to be twelve to sixteen percent annually, much higher than Malaysia's official average of 1.3%. This value incorporates a rate of underreporting of nineteen percent. The amount of non-reporting varies widely by ethnic group, from twelve to thirty-eight percent. An analysis of factors potentially influencing level of reporting suggests that it varies positively with chronicity and increased duration and severity of episodes, the latter appearing to play the greatest role.

A profile of the diarrhoeal population indicates that individuals are most at risk during infancy and early childhood (when susceptibility to multiple pathological influences is generally highest), and from age twenty to thirty-nine, probably due to secondary transmission. Contrary to past belief, the elderly have a relatively low incidence of diarrhoea.

Males appear to be slightly more vulnerable than females; again, an unusual outcome since it is widely believed that mothers of young children are most susceptive to intrafamilial transmission. Irrespective of sex, Indians have an extremely high overall rate of diarrhoea relative to their share of the population. They are also unique in that they derive most of their water from ponds and streams, leading one to infer that water supply is associated with diarrhoeal morbidity.

The analysis of risk markers of diarrhoea appears to support this conclusion. Both water supply and water treatment are significantly related to diarrhoeal outcome. However, a number of other variables are more strongly associated. In particular, there are a number of behavioural/hygiene and sanitation/infrastructural factors which have been found to have a highly significant association with self-reported diarrhoea.

"Always" boiling water, for instance, is associated with a reduction in diarrhoeal rates; other frequencies had no real impact upon high levels of incidence. Lower morbidity rates were also allied with cleanliness of the kitchen, yard and children, and sanitary condition of the water source. Three of these "hygiene" factors - boiling water, kitchen cleanliness and sanitary source - were by far the most strongly related of all factors to diarrhoea (that is, they greatly exceeded the critical values for chi-square). The impact of such factors upon morbidity has obvious implications for control interventions for diarrhoeal diseases, which will be discussed in the concluding section.

Infrastructure also plays an important role. Flush toilets, and, surprisingly, lack of a toilet or use of a bucket, were closely related to lower morbidity, as was having a sink in the house, and especially in the kitchen.

All of the above behavioural and infrastructural factors vary racially, in such a way that they demonstrate clearly the relationship between physical and cultural factors and diarrhoeal disease. That is, the Indians and the Orang Asli have extremely high rates of diarrhoeal incidence, which are strongly associated with both the poor physical environmental conditions under which they live (water and toilet facilities, etcetera) and cultural or behavioural patterns (such as child and household hygiene practices).

Many of these factors have very clear spatial patterns, and are significantly related to household location [KgPekLdg]. For instance, 97% of homes in towns have sinks, whereas only 63% in villages and 23% in estates have sinks. Forty-five percent of estate water supplies are non-JBA (25% untreated); villages have twenty percent and towns have none. Ninety-four percent of village toilet facilities are pit latrines, and ninety-two percent of estate facilities are shared. Ninety-three percent of townspeople always boil water; seventy-five percent of village people, and only forty percent of estates (22% 'never') consistently boil their water. This implies a spatial bias to diarrhoeal risk factors, and suggests a need to refocus intervention initiatives and resources on rural rather than urban areas. This is especially applicable to water provision/quality and sewage projects such as the Port Dickson and Seremban sewerage and drainage master plans, which concentrate on improving facilities to the urban areas.

Although water quality has been shown herein to influence diarrhoeal rates, the impact of water quality improvement programmes alone would likely be minimal, since they affect only the initial source. This thesis has demonstrated that there are factors in addition to infrastructural that may have a greater influence on diarrhoea. Therefore, there is a pressing need to develop parallel programs to accompany water improvement projects. In particular, hygiene education is a necessary complement to "engineering" solutions.

APPENDIX A

Preliminary Wellwater Supply Sampling

Port Dickson District

**Preliminary Wellwater Supply Sampling
Port Dickson District**

Kampongs	Well Number	Faecal Coliform / 100 ml	Non-Faecal Coliform / 100 ml
Jimah Lama	MOH	506	0
Linggi	MOH	779	0
Orang Asli/Bukit Kepong	1	3	22
Orang Asli/Bukit Kepong	2	615	32
Orang Asli/Bukit Kepong	3	35	76
Permatang Pasir	6	246	n.a.
Permatang Pasir	17	533	n.a.
Permatang Pasir	18	205	n.a.
Tampin Linggi	1	1189	0
Tampin Linggi	2	4	13

Estates	House Number	Faecal Coliform	Non-Faecal Coliform
Bradwall	estate	7	6
Dundee	estate	36	37
Jemimah	50	0	0
Jemimah	36	0	2
Jemimah	B-8	8	18

APPENDIX B

Household Diarrhoeal Morbidity Survey

English and Malay

Date: ______________________________ (day/month/year)

Address of Respondent: ______________________________
____

Name/House Number: ______________________________

Village/Town/Estate (Division): ______________________________

Sub-District: ______________________________

Sample Area Code: ______________________________

House Sample Number: ______________________________

Time of Interview:

Interview Conducted:

Inside House: ______
Outside House: ______

Name of Interviewer: ______________________________

A. Household Members

1. Could you please tell me the names and relationships (for instance, grandmother, father, child) of the people living in this home, and their race, sex and age. (Record the respondent's answer in the table below. Note whether each individual was present for the interview).

Household Members (Name/Relationship)	Race	Sex	Age	Stools/ Day	Present at Interview
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

2. Who is the person who usually takes care of the children?

   Name: ______________________ Relationship ____________________

3. What are the average number of stools per day for each individual (record under Section A Question 1)?

B. Diarrhoeal Incidence

<u>Definition</u> Diarrhoea (purging, gastro) occurs when a person has three or more liquid stools (bowel movements) per day, OR when stools are softer or more frequent than what is normal for that person.

1. Has any member of the household had diarrhoea in the last two weeks?

   Yes No

SEE OVER

If yes, answer the following questions; if no, go to question 2.

Name	No. of Stools Per Day	No. of Days	Blood or Mucus in Stool	Vomit or Fever	Doctor or Hospital
1.					
2.					
3.					
4.					
5.					
.					
.					
.					
15.					

* Please make a <u>separate</u> note of <u>each</u> occurrence of diarrhoea for all household members. This is especially important for infants and young children.

2. Has any member of the household had diarrhoea in the last three months?

Yes No

If yes, ask the following questions; if no, go to question 3.

Name	No. of Stools Per Day	No. of Days	Blood or Mucus in Stool	Vomit or Fever	Doctor or Hospital
1.					
2.					
3.					
.					
.					
.					
15.					

* Please make a <u>separate</u> note of <u>each</u> occurrence of diarrhoea...

for all household members. This is especially important for infants and young children.

3. Do household members visit a doctor or hospital when they suffer from diarrhoea?

   Yes No

C. **Breastfeeding**

If the household has an infant ask the following question, otherwise go to question 6.

4. Do you breastfeed, bottlefeed, or both?

   Breastfeed Bottlefeed Both

If both, ask the following question.

5. At what age did you (or do you plan to) give the child milk from a bottle or cup?

   2-3 months 4-6 months 7-9 months
   other ________________________________

6. In the past did you breastfeed, bottlefeed (or both) your older children?

   Breastfeed Bottlefeed Both

D. **Water Supply**

7. Is water supply:
   a. JBA b. non-JBA (treated) c. non-JBA (untreated)

If they answer b, ask the following question; otherwise go on to question 9.

8. Is your drinking water chlorinated? Yes No
   (How Frequently?) ____________________

9. What types of water supply do you use for drinking?

   a. Piped water into house
   b. Piped water into yard
   c. Community standpipe
   d. Public tank
   e. River, spring, well, catchment pond
   f. Other (specify) ____________________

If water is collected from outside the house, ask the following question; otherwise go on to question 11.

10. What do you collect your water in? ______________________
(Ask the respondent if you can see the container that household water is kept in).

11. What type of container is the household container for water?
____

12. How do household members get water out of the container (cup, hands, spoon, etc)? ______________________

13. Do you boil ALL of your household water?

Always   Frequently   Sometimes   Never

If they answer yes, ask to see the container that boiled water is stored in, and ask the following questions; if no, go to question 16.

14. What is it made of? ______________________

15. If you intend to refrigerate the water, do you boil it?

Yes   No

16. Do you experience interruptions or shortages in your water supply?

Frequently   Rarely   Never

If they experience shortages or interruptions ask the following question; otherwise go on to question 18.

17. Where do you get your water from when your usual supply is interrupted? ______________________

18. Are there times when no fuel is available for cooking?

Yes   No

If yes, does this happen often?   Yes   No

E. Sanitation

19. What type of toilet do you and your family use?

    a. Pit latrine (private)
    b. Pit latrine (shared with others)
    c. Flush toilet
    d. Public facility (septic tank or latrine)
    e. Bucket
    f. Other ______________________________

20. Is the toilet fully enclosed (walls, doors, ceiling)?

    Yes No

21. Do you use a bucket/pail at night to go to the bathroom in?

    Yes No

22. Where do you empty it? ______________________________

23. Are there times when you just don't use the toilet?

    Yes No

    If yes, then what do you use (bush, river, etc)? ____________

24. Where do you dump your garbage? (Note if it is near to the water source) ______________________________

If there is an infant in the home, ask the following question:

25. Where does the mother get rid of the waste from the child's diapers? ______________________________

26. Does the house experience flooding?

    Frequently Seldom Never

F. Observations

If the water supply is not piped, ask to see the water source.

1. If the supply is a well, is it "sanitary"?

    Yes No

2. Is there garbage or human or animal excrement around the water source?

Yes No

3. Is there a non-septic tank latrine near or above the water source? (This includes toilets near wells and those overhanging streams, etc).

4. Are the latrine and surrounding area relatively clean and free from contamination (garbage, faeces, etc)?

Yes No

5. Is there garbage, excrement, chickens, pigs, cows, goats, dogs, cats, etc in the yard (near the house)?
List all that apply ____________________
In the house? ____________________

6. Does the water source appear to be used for other activities (bathing, swimming, etc - ask the respondent if possible)?
List other uses ____________________

7. Is there a sink in the house? Yes No

8. Is there a sink in the kitchen? Yes No

9. Ask to see where the mother keeps the water supply. Describe in detail how it is kept ____________________
____
____
____

10. How clean is the children's personal self?

Very Clean | Slightly Clean | Slightly Unclean | Very Unclean

11. Are there small children sitting in the yard or playing in the dirt?

Yes No

12. Any comments you wish to make?

Tarikh: ______________________________ (hari/bulan/tahun)

Alamat Respondant: ______________________________

____

Nama/Nombor: ______________________________

Kampong/Bandar/Ladang (Division): ______________________________

Mukim: ______________________________

Kod Sampel Kawasan: ______________________________

Nombor Sampel Rumah: ______________________________

Masa/Waktu Interbiu:

Tempat Interbiu:

Didalam Rumah: ______

Diluar Rumah: ______

Nama Juru Interbiu: ______________________________

A. **Ahli Rumahtangga**

1. Bolehkah tuan/puan tolong memberikan nama dan tali persaudaraan diantara kalanangan ahli-ahli rumah (sebagai contoh nenek, bapak, anak dll) dan juga bangsa, jantina dan umur. (Rekodkan jawapan di dalam charta dibawah. Catitkan siapakah hadir untuk interbiu).

Ahli Rumahtangga (Nama/Tali) Persaudaraan	Bangsa	Jantina	Umur	Jumlah ka tandas sahari	Hadir untuk diinterbiu
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

2. Siapakah yang selalunya menjaga budak-budak kecil?

Nama: ______________________ Tali persaudaraan: ________________

3. Berapakah purata katandas sehari untuk setiap individu rumahtangga (jawab diSection A, Soalan 1)?

B. **Peristiwa Ceret-Beret**

Takrif Ceret-beret adalah dimana seseorang membuang air besar tiga kali atau lebih sehari ataupun apabila najis adalah lembik, beair ataupun apabila pembuangan air besar lebih sering berlaku daripada biasa.

1. Pernahkan ahli rumahtangga menghadapi ceret-beret ditempoh masa dua minggu lalu?

Ya Tidak

Jikalau ya, tanyalah soalan berikut; dan jikalau tidak, teruskan ke soalan 2.

Nama	Jumlah buang air sahari	Jumlah hari	Darah @ Lendir (D @ L)	Muntah @ Deman (M @ D)	Doktor @ Hospital
1.					
2.					
3.					
4.					
5.					
.					
.					
.					
15.					

* Untuk <u>setiap</u> kejadian ceret-beret dikalangan ahli rumahtangga, tuliskan disatu barisan yang <u>berlainan</u>. Ini terutamanya penting bagi bayi-bayi dan budak-budak kecil.

2. Adakah ahli-ahli rumahtangga menghadapi ceret-beret didalam tempuh tiga bulan yang lalu?

Ya Tidak

Jikalau ya, tanyalah soalan berikut; dan jikalau tidak, teruskan ke soalan 3.

Nama	Jumlah buang air sahari	Jumlah hari	Darah @ Lendir (D @ L)	Muntah @ Deman (M @ D)	Doktor @ Hospital
1.					
2.					
3.					
4.					
5.					
.					
.					
.					
15.					

* Untuk setiap kejadian ceret-beret dikalangan ahli rumahtangga,

tuliskan satu barisan yang berlainan. Ini terutamanya penting bagi bayi-bayi dan budak-budak kecil.

3. Adakah ahli-ahli rumahtangga mengambil rawatan oleh doktor atau-pun dihospital apabila menghadapi ceret-beret?

Ya Tidak

C. <u>Susu-Ibu</u>

Jikalau rumahtangga tersebut mempunyai bayi, tanyakanlah soalan berikut, jikalau tidak ada teruskanlah ke soalan 6.

4. Adakah anda memberikan susu-ibu, susu-botol, atau-pun kedua-dua?

Susu-ibu Susu-botol Kedua-dua

Jikalau kedua-dua, tanyalah soalan berikut.

5. Pada umur berapakah saudari mula memberi bayi (atau-pun mempunyai niat untuk) susu da ripada botol atau cawan?

2-3 bulan 4-6 bulan 7-9 bulan
lain-lain (terangkan) ______________________________

6. Dahulunya adakahn anaknya yang lebih tua (sulong) diberi susu-ibu, susu-botol atau kedua-dua?

Susu-ibu Susu-botol Kedua-dua

D. <u>Bekalan-Air</u>

7. Adakah bekalan air:

a. JBA b. bukan-JBA (dirawat) c. bukan-JBA (tidak rawat)

8. Adakah air dikloranka n? Ya Tidak
(Berapa kalikah?) ______________________________

9. Apakah jenis bekalan air yang digunakan?

a. Air paip kedalam rumah
b. Air paip keluar rumah
c. Paip awam
d. Tangki awam
e. Sungai atau air-mata
f. Lain-lain (terangkan) ______________________________

Jikalau air ditakong diluar rumah tanyalah soalan berikut;

jikalau tidak teruskanlah ke soalan 11.

10. Apakah yang digunakan untuk menakong air? ____________
(Boleh lah dilihat takongan yang digunakan?)

11. Apakah jenis takungan yang digunakan? ____________

12. Dengan apakah ahli-ahli rumahtangga mengeluarkan air daripada takung tersebut? (Cawan, sudu, dll) ____________

13. Adakah anda pernah memasak semua air minuman? ____________

Selalu   Sering-kali   Kadang-kali   Tidak pernah

Jikalau jawapan adalah ya, tanyalah untuk mendapat meneliti takung yang digunakan dan tanya soalan yang berikut; jikalau tidak, teruskanlah ke soalan 16.

14. Sebutkan tempat menyimpan air yang sudah masak? ____________

15. Jikalau anda mempunyai niat untuk menyimpan air dipeti sejuk adakah anda memasaknya?   Ya   Tidak

16. Adakah terdapat gangguan bekalan atau-pun "shortage" didala bekalan air?

Sering-kali   Jarang-kali   Tidak Pernah

Jikalau terdapat gangguan, tanyalah soalan berikut; jikalau tidak, teruskanlah ke soalan 18.

17. Dimanakah anda mendapat sumber air jikalau bekalan air terganggu? ____________

18. Adakah berlakunya dimana tidak ada bahan api untuk memasak?

Ya   Tidak

Jikalau ya, adakah ini berlaku sering-kali?   Ya   Tidak

E. **Kebersihan Tandas**

19. Jenis tandas yang di gunakan oleh keluarga kamu?

a. Tandas tanah (sendiri)
b. Tandas tanah (berkongsi)
c. Tandas "flush"
d. Kemudahan awam
e. Baldi
f. Lain-lain ____________

20. Adakah tandas mempunyai bumbong, dinding dan pintu?

Ya Tidak

21. Adakah anda mengginakan baldi diwaktu malam untuk ke tandas?

Ya Tidak

22. Dimanakah baldi di kosongkan? ___________________________

23. Adakah masa nya tandas tidak digunakan?

Ya Tidak

Jikalau ya, dimana digunakan? (belukar? sungai? lain-lain)

24. Dimanakah sampah di buang? ___________________________

Adakah tempat buangan sampah dekat dengan sumber air? ______

Jika adanya bayi dirumah, tanyalah soalan yang berikut:

25. Dimanakah ibu membuang najis daripada tuala bayi? _________

26. Adakah rumah tersebut mengalami banjir?

Sering-kali Jarang-kali Tidak Pernah

F. <u>Observasi/Penelitian</u>

Jikalau tidak menggunakan air paip cuba tengok sumber air.

1. Jikalau sumber air adalah perigi, adakah ia "sanitary"?

Ya Tidak

2. Adakah sampah atau najis manusia atau binatang sekitar sumber air?

Ya Tidak

3. Adakah tandas (tampa tangki septic) berdekatan atau di atas sumber air? (Ini termasuk tandas berdekatan dengan perigi dan yang diatas anak sungai).

4. Adakah tandas dan kawasan bersekitaran memuaskan dan bebas

dari kintaminasi? (najis, sampah-sarap dan kotoran yang lain).

Ya Tidak

5. Adakahnya sampah, najis ayam, babi, lembu, kambing, anjing, kucing dll di dawasan dekat dengan rumah?

Namakan: ______________________________

Didalam Rumah: ______________________________

6. Adakah nampaknya bahwa sumber air di gunakan untuk aktiviti atau perkara yang lain? (Memandi, berenang, membasuh kain dll).
Namakan Kegunaan lain jika ada: ______________________________

7. Rumah itu mempunyai "sink"? Ya Tidak

8. Adakah dapur mempunyai "sink"? Ya Tidak

9. Tengok dimana ibu, menyimpan bekalan air minuman. Terangkan dengan teliti bagaimana ia di simpan: ______________________________
____
____
____
____

10. Bagaimanakah keadaan kebersihan anak-anak?

a. Sangat bersih b. Kurang bersih c. Sedikit bersih d. Kotor

11. Adakah anak-anak kecil memduduki atau bermain dengan/dalam kotor di sekitar rumah?

Ya Tidak

12. Adakah komen-komen yang hendak dibuat?

APPENDIX C

Household Diarrhoeal Morbidity Survey

Variable Categories

Household Diarrhoeal Morbidity Survey
Variable Categories

Variable		Categories
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS		
Race	1	Chinese
	2	Indian
	3	Malay
	4	Orang Asli or other native (eg. Dayak)
NumPple	1	1-2 people
	2	3-5 people (small family)
	3	6-8 people (extended family)
	4	9-13 people
KgPekLdg	1	kampong [village]
	2	pekan [town/urban]
	3	ladang [estate]
MORBIDITY INDICATORS		
Diarrhea	1	yes
	2	no
Num_Events	#	number of episodes
Duration	0	not applicable
	1	one to seven days
	2	more than seven days
Severity	0	not applicable
	1	mild (no comorbidity)
	2	severe (comorbidity or no comorbidity but hospitalized)
	3	very severe (both comorbidity and hospitalized)
Recurrent	0	not applicable
	1	yes
	2	no
Reported	0	not applicable
	1	yes
	2	no

Gen_Report	1	yes
	2	no

RISK FACTORS

<u>Child-Care Practices</u>

CareGive	0	not applicable
	1	mother
	2	other
Breastfd	0	not applicable
	1	breastfeed
	2	bottlefeed or both breast- and bottle-feed

<u>Water Supply</u>

WatTreat	1	JBA [Department of Water Supply]
	2	non-JBA, regularly treated
	3	non-JBA, untreated
WatSupp	1	piped into house
	2	piped into yard
	4	public tank, tanker truck, river, spring, well, catchment pond, rainwater
Boil	1	always
	2	frequently/sometimes
	3	never
Shortage	1	frequent
	2	rare
	3	never

<u>Sanitation</u>

Toilet	0	none or bucket
	1	private pit latrine
	2	shared pit latrine or septic tank
	3	private flush toilet
Defecate	1	yes
	2	no
Flooding	1	frequent or seldom
	3	never

<u>Sanitation and Children's Hygiene</u> (observed)

SanWater	1	yes
	2	no
YardCln	1	yes
	2	no
KitchCln	1	yes
	2	no
SinkHse	1	yes
	2	no
SinkKit	1	yes
	2	no
ChildCln	0	not applicable
	1	very clean
	2	slightly unclean or very unclean
ChldPlay	0	not applicable
	1	yes
	2	no

NOTES

1. All unknowns were coded as '9' in DBase III and '*' in Minitab; 'not applicable' was also coded as '*' in Minitab (which eliminates this variable from chi-square calculations)

2. Individual categories which did not meet the assumptions required to perform the chi-square test (that is, no category with an expected frequency of less than 1; and not more than one category in five with an expected frequency of less than 5) were amalgamated. Categories with no values (for instance: there were no community standpipes under 'WatSupp') were eliminated.

APPENDIX D

Chi-Square Tables of Significant Variables

ROWS: Diarrhea COLUMNS: NumPple

	1	2	3	4	ALL
1	4 3.97	20 26.05	32 29.03	9 5.95	65 65.00
2	12 12.03	85 78.95	85 87.97	15 18.05	197 197.00
ALL	16 16.00	105 105.00	117 117.00	24 24.00	262 262.00

CHI-SQUARE = 4.346 WITH D.F. = 3

CELL CONTENTS —
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Race

	1	2	3	4	ALL
1	9 11.66	37 23.07	8 24.81	11 5.46	65 65.00
2	38 35.34	56 69.93	92 75.19	11 16.54	197 197.00
ALL	47 47.00	93 93.00	100 100.00	22 22.00	262 262.00

CHI-SQUARE = 34.619 WITH D.F. = 3

ROWS: Diarrhea COLUMNS: CareGive

	1	2	ALL
1	42	1	43
	39.35	3.65	43.00
2	109	13	122
	111.65	10.35	122.00
ALL	151	14	165
	151.00	14.00	165.00

CHI-SQUARE = 2.841 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: KgPekLdg

	1	2	3	ALL
1	29	5	31	65
	34.48	7.44	23.07	65.00
2	110	25	62	197
	104.52	22.56	69.93	197.00
ALL	139	30	93	262
	139.00	30.00	93.00	262.00

CHI-SQUARE = 5.849 WITH D.F. = 2
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Breastfd

	1	2	ALL
1	4 3.18	8 8.82	12 12.00
2	14 14.82	42 41.18	56 56.00
ALL	18 18.00	50 50.00	68 68.00

CHI-SQUARE = 0.353 WITH D.F. = 1

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: WatTreat

	1	2	3	ALL
1	39 47.63	5 4.71	21 12.65	65 65.00
2	153 144.37	14 14.29	30 38.35	197 197.00
ALL	192 192.00	19 19.00	51 51.00	262 262.00

CHI-SQUARE = 9.428 WITH D.F. = 2

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: WatSupp

	1	2	4	ALL
1	42	4	19	65
	48.31	6.23	10.46	65.00
2	152	21	23	196
	145.69	18.77	31.54	196.00
ALL	194	25	42	261
	194.00	25.00	42.00	261.00

CHI-SQUARE = 11.444 WITH D.F. = 2
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Boil

	1	2	3	ALL
1	21	31	13	65
	41.93	16.62	6.45	65.00
2	148	36	13	197
	127.07	50.38	19.55	197.00
ALL	169	67	26	262
	169.00	67.00	26.00	262.00

CHI-SQUARE = 39.277 WITH D.F. = 2
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Toilet

	0	1	2	3	ALL
1	6	13	16	30	65
	7.22	7.47	8.97	41.34	65.00
2	23	17	20	136	196
	21.78	22.53	27.03	124.66	196.00
ALL	29	30	36	166	261
	29.00	30.00	36.00	166.00	261.00

CHI-SQUARE = 17.216 WITH D.F. = 3
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Shortage

	1	2	3	ALL
1	16	19	30	65
	15.43	21.25	28.33	65.00
2	45	65	82	192
	45.57	62.75	83.67	192.00
ALL	61	84	112	257
	61.00	84.00	112.00	257.00

CHI-SQUARE = 0.478 WITH D.F. = 2
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Defecate

	1	2	ALL
1	20 14.78	45 50.22	65 65.00
2	38 43.22	152 146.78	190 190.00
ALL	58 58.00	197 197.00	255 255.00

CHI-SQUARE = 3.197 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: Flooding

	1	3	ALL
1	3 7.00	62 58.00	65 65.00
2	25 21.00	170 174.00	195 195.00
ALL	28 28.00	232 232.00	260 260.00

CHI-SQUARE = 3.415 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: SanWater

	1	2	ALL
1	39	26	65
	51.90	13.10	65.00
2	167	26	193
	154.10	38.90	193.00
ALL	206	52	258
	206.00	52.00	258.00

CHI-SQUARE = 21.264 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: YardCln

	1	2	ALL
1	5	60	65
	13.70	51.30	65.00
2	50	146	196
	41.30	154.70	196.00
ALL	55	206	261
	55.00	206.00	261.00

CHI-SQUARE = 9.317 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea   COLUMNS: SinkKit

	1	2	ALL
1	22	43	65
	29.14	35.86	65.00
2	95	101	196
	87.86	108.14	196.00
ALL	117	144	261
	117.00	144.00	261.00

CHI-SQUARE = 4.220 WITH D.F. = 1

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea   COLUMNS: ChildCln

	1	2	ALL
1	17	40	57
	27.69	29.31	57.00
2	86	69	155
	75.31	79.69	155.00
ALL	103	109	212
	103.00	109.00	212.00

CHI-SQUARE = 10.984 WITH D.F. = 1

ROWS: Diarrhea COLUMNS: KitchCln

	1	2	ALL
1	46	19	65
	57.75	7.25	65.00
2	185	10	195
	173.25	21.75	195.00
ALL	231	29	260
	231.00	29.00	260.00

CHI-SQUARE = 28.578 WITH D.F. = 1

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Diarrhea COLUMNS: ChldPlay

	1	2	ALL
1	8	49	57
	4.64	52.36	57.00
2	9	143	152
	12.36	139.64	152.00
ALL	17	192	209
	17.00	192.00	209.00

CHI-SQUARE = 3.652 WITH D.F. = 1

ROWS: SinkHse   COLUMNS: Race

	1	2	3	4	ALL
1	28	35	65	11	139
	25.70	49.31	52.98	11.02	139.00
2	21	59	36	10	126
	23.30	44.69	48.02	9.98	126.00
ALL	49	94	101	21	265
	49.00	94.00	101.00	21.00	265.00

CHI-SQUARE = 14.900 WITH D.F. = 3

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: SinkKit   COLUMNS: Race

	1	2	3	4	ALL
1	28	34	50	5	117
	21.63	41.50	44.59	9.27	117.00
2	21	60	51	16	148
	27.37	52.50	56.41	11.73	148.00
ALL	49	94	101	21	265
	49.00	94.00	101.00	21.00	265.00

CHI-SQUARE = 10.480 WITH D.F. = 3

ROWS: KgPekLdg COLUMNS: Race

	1	2	3	4	ALL
1	22	15	83	21	141
	25.97	49.83	53.54	11.66	141.00
2	13	3	14	0	30
	5.53	10.60	11.39	2.48	30.00
3	14	76	4	1	95
	17.50	33.57	36.07	7.86	95.00
ALL	49	94	101	22	266
	49.00	94.00	101.00	22.00	266.00

CHI-SQUARE = 156.100 WITH D.F. = 6

ROWS: ChildCln COLUMNS: Race

	1	2	3	4	ALL
1	20	24	53	6	103
	20.12	37.85	37.37	7.67	103.00
2	22	55	25	10	112
	21.88	41.15	40.63	8.33	112.00
ALL	42	79	78	16	215
	42.00	79.00	78.00	16.00	215.00

CHI-SQUARE = 22.975 WITH D.F. = 3

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: SanWater COLUMNS: Race

	1	2	3	4	ALL
1	38	72	92	6	208
	38.90	73.04	79.39	16.67	208.00
2	11	20	8	15	54
	10.10	18.96	20.61	4.33	54.00
ALL	49	92	100	21	262
	49.00	92.00	100.00	21.00	262.00

CHI-SQUARE = 43.035 WITH D.F. = 3

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: KitchCln COLUMNS: Race

	1	2	3	4	ALL
1	46	74	100	15	235
	43.62	82.78	89.91	18.69	235.00
2	3	19	1	6	29
	5.38	10.22	11.09	2.31	29.00
ALL	49	93	101	21	264
	49.00	93.00	101.00	21.00	264.00

CHI-SQUARE = 26.630 WITH D.F. = 3

ROWS: Boil   COLUMNS: Race

	1	2	3	4	ALL
1	34	42	84	12	172
	31.68	60.78	65.31	14.23	172.00
2	15	28	16	9	68
	12.53	24.03	25.82	5.62	68.00
3	0	24	1	1	26
	4.79	9.19	9.87	2.15	26.00
ALL	49	94	101	22	266
	49.00	94.00	101.00	22.00	266.00

CHI-SQUARE =   55.833   WITH D.F. =   6

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Toilet   COLUMNS: Race

	1	2	3	4	ALL
0	16	5	7	1	29
	5.36	10.18	11.05	2.41	29.00
1	8	6	6	11	31
	5.73	10.88	11.82	2.57	31.00
2	9	26	1	1	37
	6.84	12.98	14.10	3.07	37.00
3	16	56	87	9	168
	31.06	58.96	64.03	13.95	168.00
ALL	49	93	101	22	265
	49.00	93.00	101.00	22.00	265.00

CHI-SQUARE =   104.328   WITH D.F. =   9

ROWS: WatTreat   COLUMNS: Race

	1	2	3	4	ALL
1	37	59	92	7	195
	35.92	68.91	74.04	16.13	195.00
2	1	18	0	0	19
	3.50	6.71	7.21	1.57	19.00
3	11	17	9	15	52
	9.58	18.38	19.74	4.30	52.00
ALL	49	94	101	22	266
	49.00	94.00	101.00	22.00	266.00

CHI-SQUARE =   73.298   WITH D.F. =   6

CELL CONTENTS --

COUNT

EXP FREQ

ROWS: WatSupp   COLUMNS: Race

	1	2	3	4	ALL
1	38	77	76	6	197
	35.68	69.88	75.08	16.35	197.00
2	3	7	15	1	26
	4.71	9.22	9.91	2.16	26.00
4	7	10	10	15	42
	7.61	14.90	16.01	3.49	42.00
ALL	48	94	101	22	265
	48.00	94.00	101.00	22.00	265.00

CHI-SQUARE =   53.766   WITH D.F. =   6

ROWS: ChldPlay   COLUMNS: Defecate

	1	2	ALL
1	8	8	16
	3.86	12.14	16.00
2	42	149	191
	46.14	144.86	191.00
ALL	50	157	207
	50.00	157.00	207.00

CHI-SQUARE = 6.323 WITH D.F. = 1
CELL CONTENTS --
COUNT
EXP FREQ

ROWS: WatTreat   COLUMNS: KgPekLdg

	1	2	3	ALL
1	113	30	52	195
	103.36	21.99	69.64	195.00
2	0	0	19	19
	10.07	2.14	6.79	19.00
3	28	0	24	52
	27.56	5.86	18.57	52.00
ALL	141	30	95	266
	141.00	30.00	95.00	266.00

CHI-SQUARE = 49.942 WITH D.F. = 4

ROWS: WatSupp COLUMNS: KgPekLdg

	1	2	3	ALL
1	94	28	75	197
	104.82	21.56	70.62	197.00
2	14	1	11	26
	13.83	2.85	9.32	26.00
4	33	0	9	42
	22.35	4.60	15.06	42.00
ALL	141	29	95	265
	141.00	29.00	95.00	265.00

CHI-SQUARE = 16.925 WITH D.F. = 4

CELL CONTENTS —

COUNT

EXP FREQ

ROWS: Shortage COLUMNS: KgPekLdg

	1	2	3	ALL
1	31	18	14	63
	33.31	7.24	22.45	63.00
2	41	7	36	84
	44.41	9.66	29.93	84.00
3	66	5	43	114
	60.28	13.10	40.62	114.00
ALL	138	30	93	261
	138.00	30.00	93.00	261.00

CHI-SQUARE = 27.241 WITH D.F. = 4

ROWS: Toilet   COLUMNS: KgPekLdg

	1	2	3	ALL
0	12	11	6	29
	15.43	3.28	10.29	29.00
1	29	1	1	31
	16.49	3.51	11.00	31.00
2	5	0	32	37
	19.69	4.19	13.12	37.00
3	95	18	55	168
	89.39	19.02	59.59	168.00
ALL	141	30	94	265
	141.00	30.00	94.00	265.00

CHI-SQUARE =   84.104   WITH D.F. =   6

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Flooding   COLUMNS: KgPekLdg

	1	2	3	ALL
1	20	8	0	28
	14.85	3.18	9.97	28.00
3	120	22	94	236
	125.15	26.82	84.03	236.00
ALL	140	30	94	264
	140.00	30.00	94.00	264.00

CHI-SQUARE =   21.314   WITH D.F. =   2

ROWS: Boil   COLUMNS: KgPekLdg

	1	2	3	ALL
1	106	28	38	172
	91.17	19.40	61.43	172.00
2	31	1	36	68
	36.05	7.67	24.29	68.00
3	4	1	21	26
	13.78	2.93	9.29	26.00
ALL	141	30	95	266
	141.00	30.00	95.00	266.00

CHI-SQUARE =   50.311   WITH D.F. =   4

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: Boil   COLUMNS: Race

	1	2	3	4	ALL
1	34	42	84	12	172
	31.68	60.78	65.31	14.23	172.00
2	15	28	16	9	68
	12.53	24.03	25.82	5.62	68.00
3	0	24	1	1	26
	4.79	9.19	9.87	2.15	26.00
ALL	49	94	101	22	266
	49.00	94.00	101.00	22.00	266.00

CHI-SQUARE =   55.833   WITH D.F. =   6

ROWS: Boil COLUMNS: SanWater

	1	2	ALL
1	145 133.37	23 34.63	168 168.00
2	48 53.98	20 14.02	68 68.00
3	15 20.64	11 5.36	26 26.00
ALL	208 208.00	54 54.00	262 262.00

CHI-SQUARE = 15.616 WITH D.F. = 2

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: WatTreat COLUMNS: SanWater

	1	2	ALL
1	173 153.22	20 39.78	193 193.00
2	16 15.08	3 3.92	19 19.00
3	19 39.69	31 10.31	50 50.00
ALL	208 208.00	54 54.00	262 262.00

CHI-SQUARE = 65.004 WITH D.F. = 2

ROWS: WatTreat COLUMNS: WatSupp

	1	2	4	ALL
1	164	25	5	194
	144.22	19.03	30.75	194.00
2	19	0	0	19
	14.12	1.86	3.01	19.00
3	14	1	37	52
	38.66	5.10	8.24	52.00
ALL	197	26	42	265
	197.00	26.00	42.00	265.00

CHI-SQUARE = 152.078 WITH D.F. = 4

CELL CONTENTS --

COUNT

EXP FREQ

ROWS: SinkHse COLUMNS: KgPekLdg

	1	2	3	ALL
1	88	29	22	139
	73.43	15.74	49.83	139.00
2	52	1	73	126
	66.57	14.26	45.17	126.00
ALL	140	30	95	265
	140.00	30.00	95.00	265.00

CHI-SQUARE = 62.282 WITH D.F. = 2

ROWS: Diarrhea COLUMNS: SinkHse

	1	2	ALL
1	26	39	65
	34.12	30.88	65.00
2	111	85	196
	102.88	93.12	196.00
ALL	137	124	261
	137.00	124.00	261.00

CHI-SQUARE = 5.415 WITH D.F. = 1

CELL CONTENTS --
COUNT
EXP FREQ

ROWS: SinkKit COLUMNS: KgPekLdg

	1	2	3	ALL
1	65	25	27	117
	61.81	13.25	41.94	117.00
2	75	5	68	148
	78.19	16.75	53.06	148.00
ALL	140	30	95	265
	140.00	30.00	95.00	265.00

CHI-SQUARE = 28.506 WITH D.F. = 2

BIBLIOGRAPHY

Agarwal, A. (1979) A cure for a killer - but how to deliver it? Nature vol. 278: 389-391

Anonymous (1985) Does malnutrition predispose children to diarrhoea? Nutrition Reviews vol. 43(5): 144-145

Azurin, J.C. and M. Alvero (1974) Field evaluation of environmental sanitation measures against cholera. Bulletin of the World Health Organization vol. 51: 19-26

Belcher, D.W., A.K. Neumann, F.K. Wurapa and I.M. Lourie (1976) Comparison of morbidity interviews with a health examination survey in rural Africa. American Journal of Tropical Medicine and Hygiene vol. 23: 751-758

Belloc, N.B. (1954) Validation of morbidity survey data by comparison with hospital records. Journal of American Statistical Association vol. 49: 832-836

Bertrand, W.E. and B.F. Walmus (1983) Maternal knowledge, attitudes and practice of predictors of diarrhoeal disease in young children. International Journal of Epidemiology vol. 12(2): 205-210

Black, R.E., K.H. Brown, S. Becker, A.R.M. Abdul Alim and I. Huq (1982a) Longitudinal studies of infectious diseases and physical growth of children in rural Bangladesh. II. Incidence of diarrhoea and association with known pathogens. American Journal of Epidemiology vol. 115: 315-324

Black, R.E., K.H. Brown, S. Becker and M. Yunus (1982b) Longitudinal studies of infectious diseases and physical growth of children in rural Bangladesh. I. Patterns of morbidity. American Journal of Epidemiology vol. 115: 305-314

Black, R.E., H.B. Greenberg, A.Z. Kapikian, K.H. Brown and S. Becker (1982c) Acquisition of serum antibody to norwalk virus and rotavirus and relation to diarrhoea in a longitudinal study of young children in rural Bangladesh. The Journal of Infectious Diseases vol. 145(4): 483-489

Blum, D. and R.G. Feachem (1983) Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: problems of methodology. International Journal of Epidemiology vol. 12: 357-365

Brandt, C.D., H.W. Kim, W.J. Rodriguez, J.O. Arrobio, B.C. Jeffries, E.P. Stallings, C. Lewis, A.J. Miles, R.M. Chanock, A.Z. Kapikian and R.H. Parrott (1983) Pediatric viral gastroenteritis during eight years of study. Journal of Clinical Microbiology vol.18: 71-78

Chandler, A.C. (1954) A comparison of helminthic and protozoan infections in two Egyptian villages two years after the installation of sanitary improvements in one of them. American Journal of Tropical Medicine and Hygiene vol. 3: 59-73

Chen, L.C., E. Hug and S.L Huffman (1981) A prospective study of the risk of diarrhoeal disease acording to the nutritional status of children. American Journal of Epidemiology vol. 114(2): 284-292

Chen, S.T. (1984) Bacterial diarrhoea in children. Epidemiology and Management of Diarrhoea in Children of South East Asia (First Ross Roundtable)

Cukor, G. and N.R. Blacklow (1984) Human viral gastroenteritis. Microbiological Reviews vol. 48(2): 157-179

Cutting, W.A.M. (N.D.) Oral therapy at home for diarrhoea. Diarrhoeal Disease and Malnutrition

Cvjetanovic, B. and D.V. Subrahmanyam (1985) Health Benefits of Environmental Sanitation. (World Health Organization)

Dionysius, G. (1986) Chief Health Inspector, District of Port Dickson. Personal Communication. Ministry of Health, Port Dickson

Esrey, S.A., R.G. Feachem and J.M. Hughes (1985) Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. Bulletin of the World Health Organisation vol. 63(4): 757-72

Etlin, D., J. Milner and N.F. White (1981) An ecologicalinteractional view of disease. The Health Conundrum: Explorations in Health Studies N. White (ed.) (Toronto, Ontario Educational Communications Authority)

Evison, L.M. and A. Jones (1973) A comparison of the distribution of intestinal bacteria in British and East African water sources. Journal of Applied Bacteriology vol. 36: 109-118

Feachem, R.G. (1983) Interventions for the control of diarrhoeal diseases among young children: supplementary feeding programmes. Bulletin of the World Health Organization vol. 61: 967-979. As cited in A. Ashworth and R.G. Feachem (1985) Interventions for the control of diarrhoeal diseases among young children: weaning education. Bulletin of the World Health Organization vol. 63(6): 1115-1127

Feachem, R.G. (1984) Interventions for the control of diarrhoeal diseases among young children: promotion of personal and domestic hygiene. Bulletin of the World Health Organization vol. 62(3): 467-476

Feachem, R.G., R.C. Hogan and M.H. Merson (1983) Diarrhoeal disease control: reviews of potential interventions. Bulletin of the World Health Organization vol. 61(4): 637-640

Fishbein, M. and I. Ajzen (1975) Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research (Massachusetts, Addison-Wesley Publishing Company)

Fishbein, M. and I. Ajzen (1980) Attitude and behaviour. Understanding Attitudes and Predicting Social Behaviour (New Jersey, Prentice-Hall)

Foege, W.H. and D.A. Henderson (1986) Management priorities in primary health care. Reviews of Infectious Diseases vol. 8: 313-321

Freij, L. and S. Wall (1977) Exploring Child Health and its Ecology. The Kirkos Study in Addis Abeba: An Evaluation of Procedures in the Measurement of Acute Morbidity and a Search for Causal Structure (Sweden, University of Umea and Goteborg). As cited in A. Kroeger (1983) Health interview surveys in developing countries: a review of the methods and results. International Journal of Epidemiology vol. 12: 465-481

Gordan, J.E., M. Behar and N.S. Scrimshaw (1964) Acute diarrhoeal disease in less developed countries. An epidemiological basis for control. Bulletin of the World Health Organization vol. 31: 1

Gordan, J.E., M.A. Guzman, W. Ascoli and M.S. Scrimshaw (1964) Acute diarrhoeal disease in less developed countries 2. Patterns of epidemiological behaviour in rural Guatemalan villages. Bulletin of the World Health Organisation vol. 31: 9-20

Government of Malaysia (1982) Master Plan and Feasibility Study for Sewerage and Drainage Systems in Seremban (Engineering and Environmental Consultants Sdn. Bhd. and Associates with Engineering - Science Inc.)

Henry, F.J. (1981) Environmental sanitation, infection and nutritional status of infants in rural St. Lucia, West Indies. Transactions of the Royal Society of Tropical Medicine and Hygiene vol. 75: 507-513

Hughes, J.M. (1983) Potential impacts of improved water supply and excreta disposal on diarrhoeal disease morbidity. An assessment based on a review of published studies. World Health Organisation. Diarrhoeal Disease Control Programme, Consultation Report

Isely, R.B. (1982) Evaluating the role of health education strategies in the prevention of diarrhea and dehydration. Journal of Tropical Pediatrics vol. 228: 253-261

Jellife, R.J. and J.P. Stanfield (1976) Diarrhoeal disease. Disease of Children in the Subtropics and Tropics (London)

Khan, M.U., W.H. Mosely, J. Chakraborty, A.M. Sarder and M.R. Khan (1981) The relationship of cholera to water source and use in rural Bangladesh. International Journal of Epidemiology vol. 10: 23-5

Kosa, J., J.J. Alpert and R.J. Haggerty (1967) On the reliability of family health information. Social Science and Medicine vol. 1: 165-181

Kroeger, A. (1983) Health interview surveys in developing countries: a review of the methods and results. International Journal of Epidemiology vol. 12: 465-481

Gordan, J.E., M. Behar and N.S. Scrimshaw (1964) Acute diarrhoeal disease in less developed countries. An epidemiological basis for control. Bulletin of the World Health Organization vol. 31: 1

Gordan, J.E., M.A. Guzman, W. Ascoli and M.S. Scrimshaw (1964) Acute diarrhoeal disease in less developed countries 2. Patterns of epidemiological behaviour in rural Guatemalan villages. Bulletin of the World Health Organisation vol. 31: 9-20

Government of Malaysia (1982) Master Plan and Feasibility Study for Sewerage and Drainage Systems in Seremban (Engineering and Environmental Consultants Sdn. Bhd. and Associates with Engineering - Science Inc.)

Henry, F.J. (1981) Environmental sanitation, infection and nutritional status of infants in rural St. Lucia, West Indies. Transactions of the Royal Society of Tropical Medicine and Hygiene vol. 75: 507-513

Hughes, J.M. (1983) Potential impacts of improved water supply and excreta disposal on diarrhoeal disease morbidity. An assessment based on a review of published studies. World Health Organisation. Diarrhoeal Disease Control Programme, Consultation Report

Isely, R.B. (1982) Evaluating the role of health education strategies in the prevention of diarrhea and dehydration. Journal of Tropical Pediatrics vol. 228: 253-261

Jellife, R.J. and J.P. Stanfield (1976) Diarrhoeal disease. Disease of Children in the Subtropics and Tropics (London)

Khan, M.U., W.H. Mosely, J. Chakraborty, A.M. Sarder and M.R. Khan (1981) The relationship of cholera to water source and use in rural Bangladesh. International Journal of Epidemiology vol. 10: 23-5

Kosa, J., J.J. Alpert and R.J. Haggerty (1967) On the reliability of family health information. Social Science and Medicine vol. 1: 165-181

Kroeger, A. (1983) Health interview surveys in developing countries: a review of the methods and results. International Journal of Epidemiology vol. 12: 465-481

Krugman, S. and S.I. Katz (1981) Infectious Diseases of Children (London, Mosby) pp.63-76

Kumar, P., B.S. Sehgal and R. Singh (1970) Bore-hole disposal of excreta of children and diarrhoeal morbidity in a rural community. Environment and Health vol. 12: 155-159

Lam, S.K. (1985) Personal Communication. Department of Medical Microbiology, University Hospital, University of Malaya

Linggi River Basin Project (1985) Interim Report (Institute of Advanced Studies, University of Malaya, unpublished)

Lo, E.K.C. (1985) Assistant Director of Health. Personal Communication. Epidemiology Unit, Ministry of Health, Kuala Lumpur

Lo, E.K.C. (N.D.) Surveillance of Diarrhoeal Diseases in Malaysia

Lutz, W. (1982) Sampling: How to Select People, Households, Places to Study Community Health (Geneva, International Epidemiological Association)

Lye, M. S. (1984) Diarrhoeal diseases in rural Malaysia: risk factors in young children. Annals of the Academy of Medicine, Singapore vol. 13: 156-162

Mata, L. (1983) Epidemiology of acute diarrhoea in childhood. Acute Diarrhoea: Its Nutritional Consequences in Children J.A. Bellanti (ed.) (New York, Raven Press)

May, J. (1961) Studies in Disease Ecology (New York, Hafner Publishing Company)

McGregor, I.A., A.K. Rahman, A.M. Thomson, W.Z. Billewicz and B. Thompson (1970) The health of young children in a West African (Gambian) village. Transactions of the Royal Society of Tropical Medicine and Hygiene vol. 65(1): 48-77

Mechanic, D. and M. Newton (1965) Some problems in the analysis of morbidity data. Journal of Chronic Disease vol. 18: 569-580

Ministry of Health (1983a) National Programme on Drinking Water Quality Surveillance (Kuala Lumpur, Drinking

Water Quality Surveillance Unit, Division of Engineering Services)

Ministry of Health (1983b) Manual on Drinking Water Quality Surveillance (Kuala Lumpur, Drinking Water Quality Surveillance Unit, Division of Engineering Services)

Ministry of Health (1983c) National Guidelines for Drinking Water Quality (Kuala Lumpur, Drinking Water Quality Surveillance Unit, Division of Engineering Services)

Mohan, Jai (1985) Ipoh State Paediatrician. Personal Communication. General Hospital, Ipoh

Moore, H.A., E. de la Cruz and O. Vargas-Mendez (1965) Diarrheal disease studies in Costa Rica: IV The influence of sanitation upon the prevalence of intestinal infection and diarrheal disease. American Journal of Epidemiology vol. 82: 162-184

Moore, H.A., E. de la Cruz and O. Vargas-Mendez (1966) Diarrheal disease studies in Costa Rica: I Plan and method of investigation. American Journal of Public Health vol. 56: 276-286

Morley, D. (1973) Diarrhoea. In Paediatric Priorities in the Developing World (London)

Myers, J. (1982) Human behaviour-ecological model of disease causation: diarrhoeal disease among preschool children in Grenada. (McMaster University, unpublished research proposal)

Nazer, H. (1982) Acute diarrhoea in the developing world. Journal of Tropical Pediatrics vol. 28: 1

Othman, R.Y. (1985) Personal Communication. Department of Genetics and Cell Biology, University of Malaya

Othman, R.Y., V. Sadandan, N.B. Rasool and S.K. Lam (1985) Rapid Diagnosis of an Outbreak of Rotavirus Diarrhoea. (Unpublished)

Population Information Program (1984) Oral rehydration therapy for childhood diarrhea. Population Reports Series L, no. 2

Rahaman, M.M., K.M.S. Aziz, Y. Patwari and M.H. Munshi (1979) Diarrhoeal mortality in two Bangladeshi villages with and without community-based oral rehydration therapy. _Lancet_ vol. 2(11): 809-812

Rahaman, M.M., M.A.L. Mia and A.R. Khan (1977) A survey of basic health information of rural Bangladesh. _Bangladesh Medical Research Council Bulletin_ vol.3: 70-76

Risyakaran, K., G.W. Loh and F. Suleiman (1984) _Preliminary Feasibility Study for the Sewerage and Drainage Systems for Port Dickson and its Urban Conurbations_ (Kuala Lumpur, Ministry of Health Malaysia)

Rodriguez, W.J., H.W. Kim, J.O. Arrobio, C.D. Brandt, R.M. Chanock, A.Z. Kapikian, R.G. Wyatt and R.H. Parrott (1977) Clinical features of acute gastroenteritis associated with human reovirus-like agent in infants and young children. _Journal of Pediatrics_ vol. 91: 188-193

Scrimshaw, N.J., C.E. Taylor and J.E. Gordon (1968) Interactions of nutrition and infection. _World Health Organization Monograph Series no. 57_

Sharma, V., R. Sharma and B.K. Purohit (1979) A longitudinal study of morbidity in children up to 5 years in an urban community. _Indian Journal of Medical Research_ vol. 69: 457

Simmons, W.R. and E.E. Bryant (1962) An evaluation of hospitalization data from the health interview survey. _American Journal of Public Health_ vol. 52: 1638-1647

Snyder, J.D. and M.H. Merson (1982) The magnitude of the global problem of acute diarrhoeal disease: a review of active surveillance data. _Bulletin of the World Health Organization_ vol. 60(4): 605-613

Taylor, S.M. (1986) Personal Communication. Department of Geography, McMaster University

Taylor, S.M., J. Myers and N.F. White (1985a) Modelling the incidence of childhood diarrhoea. (Abstract, McMaster University)

Taylor, S.M., J. Myers, N.F. White and J. Frank (1985b) Modelling the incidence of childhood diarrhoea. Paper presented at the joint AAG and IBG Medical Geography Speciality Groups, Nottingham University

Teng, S.C. (1985) _Drinking Water Quality Control Programme:_

Rembau/Tampin District (Tampin, unpublished report to the Director, Health and Medical Services, Negri Sembilan; translated from Malay)

Thomson, J.A. (1981) Inadequacy of Escherichia coli as an indicator of water pollution in a tropical climate: a preliminary study in Botswana. South African Journal of Science vol. 77: 44-45

Tomkins, A. (1981) Nutritional status and severity of diarrhoea among pre-school children in rural Nigeria. Lancet vol. 1: 860-862

Trowbridge, F.L., L.H. Newton and C.C. Campbell (1981) Nutritional status and severity of diarrhoea. Lancet vol. 1: 1375

Tugwell, P., K.J. Bennett, D. Sackett and B. Haynes (1984) Relative risks, benefits, and costs of intervention. Tropical and Geographical Medicine K.S. Warren and A.A.F. Mahmoud (eds.) (New York, McGraw-Hill)

Walsh, J.A. (1986) Prioritizing for Primary Health Care: Methods for Data Collection and Analysis

Walsh, J.A. and K.S. Warren (1979) Selective primary health care: an interim strategy for disease control in developing countries. New England Journal of Medicine vol. 301: 967-974

Wellin, E. (1977) Theoretical orientations in medical anthropology: continuity and change over the past half century. Culture, Disease, and Healing: Studies in Medical Anthropology David Landy (ed.)(New York, MacMillan Publishing Company)

White, N.F. (1986) Conceptual models: a synopsis. Health Science 771 Reference Paper

Wilson, R. (1970) The Sociology of Health: An Introduction (New York, Random House)

Wolff, H.L., W.J van Zijl and M. Roy (1969) Houseflies, the availability of water, and diarrhoeal diseases. Bulletin of the World Health Organization vol. 41: 952-959

Woolsey, T.D., P.S. Lawrence and E. Balamuth (1962) An evaluation of chronic disease prevalence data from the health interview survey. American Journal of Public

Health vol. 52: 1631-1637

World Health Organization (1979a) Global Diarrhoeal Diseases Control Programme: intercountry consultation to develop a regional programme on diarrhoeal diseases services and research M.H. Merson (New Delhi)

World Health Organization (1979b) Overview of Environmental Health in the Wider Caribbean Raymond Reid (ed.) (Washington D.C.)

Yap, K.L. (1985) Personal Communication. Department of Microbiology, Faculty of Medicine, National University of Malaysia