Seasonal Effects on the Reported Incidence of Acute Diarrhoeal Disease in Northeast Thailand

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This paper examines the seasonal variation in the reported incidence of acute diarrhoea for selected areas in the northeast of Thailand. Charts are presented which show rainfall, temperature and reported incidence of acute diarrhoea for the period 1982 to 1987. Incidence of diarrhoea appears to be inversely related to a sharp decrease in temperature around January each year. Although rainfall does not appear to have a direct effect on the relative incidence of acute diarrhoea, there is always a consistent reduction during July or August, after the rains have begun. Seasonal changes in climate may be indirectly related to other factors which have an important bearing on diarrhoeal disease. Rainwater collection is an important water source in this region and the effect this has on water use is discussed in relation to faeco-oral disease transmission.

Diarrhoeal disease is one of the major causes of morbidity in Thailand and in recent years there has been a concerted effort by the Ministry of Public Health (MOPH) to reduce this problem. The average annual incidence of diarrhoea reported to the MOPH was 694 per 100 000 (1978–1983).1 Young children are most affected with a reported annual incidence of 2952 per 100 000 for children under five years. However the actual figure is likely to be much higher and surveys indicate a frequency of around two episodes per child per year.2,3 The burden that this disease imposes on health services has meant that preventative strategies have generally been favoured, with water supply and sanitation interventions proposed as a major component of this approach.

An insight into the mechanisms of the spread of diarrhoea would assist in the design of cost-effective public health strategies. However, such is the complexity of this disease that studies conducted in Thailand and other developing countries have shown only about 50% (or less) of diarrhoeal incidence results from infection by a known pathogen.4–8 Rotavirus usually infects young children,4–8 and studies in Thailand found this to be the most frequent cause of diarrhoea in children under two years of age.9–11 Other common agents of diarrhoea in Thailand include enterotoxigenic Escherichia coli (ETEC), enteropathogenic E. coli (EPEC), Campylobacter, Shigella, Giardia lamblia and Salmonella.12–15

Rotavirus infections are commonly associated with winter diarrhoea, while most bacterial diarrhoea predominates during warm and wet seasons.9 In rural northeast Brazil rotavirus diarrhoea peaked in the cooler dry months whereas ETEC infections increased in the warmer months just before and during the rainy season.5 A similar pattern emerged in rural Bangladesh,4 furthermore it was found that ETEC diarrhoea and faecal contamination of weaning foods both appeared to be positively related to the mean monthly temperature.14 Another study in the Gambia has shown wet season peaks of diarrhoea coinciding with increased contamination of weaning foods.15 In northeast Thailand rotavirus infection has also tended to peak during the cool dry months, whereas bacterial diarrhoea has shown peaks in the hot, dry months and the initial months of the rainy season.9,12,16,17

The aim of this study was to investigate in some detail the relationship between the seasonal climatic pattern and the seasonality of the reported incidence of acute diarrhoea in northeast Thailand.
MATERIALS AND METHODS
Data on rainfall, temperature and reported incidence of acute diarrhoea for the period 1982–1987 were collated for 10 of the 17 changwats (provinces) in the northeast region of Thailand and 15 of the 20 amphurs (districts) in Changwat Khon Kaen. Only a few of these charts are presented in this paper as a representative sample. Weather stations were located at the provincial capitals and most of the amphurs; the data on climate were provided by the Department of Meteorology, Bangkok and Khon Kaen.

The MOPH have developed a national disease surveillance system where all hospitals, health centres and clinics are requested to report occurrence of 55 notifiable diseases/conditions, most of which are infectious diseases, to provincial health officers. By 1985, all 73 changwats and 86% of 621 amphurs were covered by provincial and district hospitals respectively. Amphurs are further subdivided into 6283 tambons (population 5–10 000) which all have at least one health centre. The notification cards are further submitted to the MOPH where country data are collected, analysed and reported. Data for this study were obtained from the Division of Epidemiology, MOPH in Khon Kaen and Bangkok.

Only data for the incidence of acute diarrhoea are included in the charts as these are by far the most numerous episodes when compared to other categories of diarrhoea as defined by the MOPH. For example, it has been shown that from 1978–1983 the majority of cases reported were acute diarrhoea (77%), followed by dysentery (12.2%), food poisoning (6.3%), enteric fever (3.5%) and cholera (0.6%). The passage of three or more watery stools in 24 hours (12 hours for children less than 12 months old) is usually reported as acute diarrhoea and dysentery is reported where these stools contain blood or mucus. All other diarrhoeal categories require stricter definitions.

Background
Thailand is divided into four geographical regions (Figure 1). The northeast region occupies about one-third of the land area (170 000 sq km) and contains about a third of the population (18 million), most of whom live in rural areas (90%). This is the poorest region of Thailand and for the most part, relies on subsistence agricultural production of glutinous rice. About 90% of the area is dependant on rainfed cultivation. Most villagers carry water to their homes and only 4.2% of households are served by a piped water supply. Perennial streams are rare in the northeast and the most common water sources are rain collection from roofs and gutters, shallow dug wells, tubewells with handpumps and man-made ponds.

The climate in the northeast is influenced by two seasonal monsoons which create three typical seasons during the year: hot, rainy and cool. The hot season starts with the cessation of the North East Monsoon, around the middle of February, and ends around mid-May. High temperatures (up to 40°C), low rainfall and low humidity persist throughout this period. The rainy season begins in mid-May and ends around mid-October, it is a period of frequent and heavy rainfall, high humidity and tropical temperatures. This is followed by the cool dry season when the lowest temperatures prevail with a daily range of as much as 20°C.

The northeast Region has the greatest seasonal variation in reported diarrhoeal incidence. In the southern Region for example, the seasonal variation is much less dramatic (Figure 2). Climatic conditions in these two regions are markedly different as the southern peninsular has a tropical climate with the greatest rainfall, longest rainy season and least seasonal variation in temperature.

RESULTS
The reported incidence of acute diarrhoea has tended to increase annually during the study period (Figures 3 to 5). The highest annual incidence rate occurred in two of the poorest changwats of this region, Loei and Mukdahan (around 2000 per 100 000), and this is almost four times greater than the lowest rate, Nong Khai (546). There is, however, a large discrepancy between some of the population figures obtained from different sources. This may be due to the methodological differences in recording demographic data as many people in the northeast are migrant workers who are absent semi-permanently but may still be recorded as residents.

The peaks and troughs reflect a similar pattern in both changwats and amphurs, but the similarity between the diarrhoea curves is more striking in changwats. The only consistent association between reported incidence of acute diarrhoea and temperature appears to be an inverse relationship during the winter months. Generally this peak appears more pronounced during the coldest winters. High incidence of acute diarrhoea also occurs in the hot season and at the beginning of the rainy season. However, the major consistent seasonal change is a steep reduction of diarrhoeal incidence which occurs around the middle of the rainy season during the months of July and August. Interestingly, the time of year at which this reduction occurs appears to be fairly constant for each amphur but the seasonal pattern appears with a greater regularity and consistency in the changwat charts.

The general increase in the reported incidence of
LEGEND:

Border of Thailand .................................................. —
Regional Boundary .................................................... —
Changwat (Province) Boundary ..................................... —
Capital of Thailand ................................................... ●
Provincial Capital (same name as Changwat) ............... ●
Changwat Name ...................................................... SURIN
Project Area ............................................................

Scale 20 50 100 150 200 Kilometres

FIGURE 1  Map of northeast Thailand.
acute diarrhoea is not so marked in the principle amphur (Muang) as it is in some of the other amphurs (Figure 6). This may reflect the better facilities available at the provincial capital and hence a greater consistency in the reporting procedure. It is interesting that the two amphurs with the lowest reported incidence rate have the highest proportion of residents living in municipal areas where piped water supplies with in-house connections predominate. The highest incidence rate for an amphur (2082 per 100,000 population) is nearly four times the rate of Amphur Muang (569).

An example of age-specific diarrhoea incidence is provided in Figure 7 for the year 1986 (Changwat Khon Kaen), a breakdown of diarrhoea incidence by age is not available prior to this year. Winter diarrhoea is much more prevalent in young children (<2 years) than adults where the highest incidence rates are found in the hot season and early in the rainy season. The relative incidence of winter diarrhoea decreases with age, while the hot and rainy season diarrhoea peaks become more pronounced as age increases. Although there are far less reported cases of dysentery than acute diarrhoea, Figure 8 shows that high incidence of dysentery occurs at the same time as the peaks of adult diarrhoea in Figure 7.

DISCUSSION
There is little information available concerning the relationship between reported incidence of diarrhoea and actual incidence or the biases that may occur at the different recording institutions. However the Department of Epidemiology has been continually trying to improve the reporting procedure and this may well explain the consistent increase in the reported incidence of acute diarrhoea. Similar findings have been reported for the period 1978–1982 and it is suggested that this may be partly due to improved surveillance and reporting procedures. Active surveillance reveals that most diarrhoea cases are not reported, while one small study found that underreporting was far more common in adults than young children. It is assumed that the reported incidence is proportional to actual incidence, but this proportion may differ between amphurs and changwats, and may change over time.

From this data alone it is not possible to know which causative agents are predominant at different times of the year, but evidence suggests that rotavirus may be the most prevalent agent during the cooler months. The peak of childhood diarrhoea in January (Figure 7) supports the suggestion, as rotavirus is generally more common in young children (<2 years) than adults. Rotavirus is generally regarded as a winter diarrhoea, particularly in temperate climates. However in some tropical countries fluctuations in temperature are not significant and dry or wet season peaks may occur. In north Thailand where winters are colder...
FIGURE 3 Changwat Khon Kaen, reported incidence of acute diarrhoea, total rainfall (mm) and mean temperature (°C) during 1982 to 1987. Population (1987): 1,633,000. Reported incidence rate of diarrhoea (1986): 788 (per 100,000).

FIGURE 4 Changwat Udon Thani, reported incidence of acute diarrhoea, total rainfall (mm) and mean temperature (°C) during 1982 to 1987. Population (1987): 1,663,000. Reported incidence rate of diarrhoea (1986): 689 (per 100,000).
Changwat Ubon Ratchathani. reported incidence of acute diarrhoea, total rainfall (mm) and mean temperature (°C) during 1982 to 1987. Population (1987): 1,733,000. Reported incidence rate of diarrhoea (1986): 780 (per 100,000).

than the northeast and Bangkok where winters are warmer, rotavirus still peaked in the coolest months.\textsuperscript{11,22,23} Diurnal temperature variation can be quite severe in the cool season and this may be an important factor in tropical countries where changes in the seasonal mean are not so great.

Bacterial pathogens are usually more common in both hot and wet months of the year.\textsuperscript{5,7,20,24,25} and stud-

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{diarrhea_plot}
\caption{Age-specific incidence of acute diarrhoea for Changwat Khon Kaen 1986.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{dysentery_plot}
\caption{Average reported incidence of dysentery diarrhoea for Changwat Khon Kaen during the years 1982–1987.}
\end{figure}
ies have also associated these months with increased faecal contamination of weaning foods. In north-east Thailand seasonal peaks of ETEC, Campylobacter jejuni and Shigella diarrhoea have been found in the hot and early rainy seasons. These seasonal peaks in diarrhoea appear to exist in all age groups but become more pronounced with increasing age as winter diarrhoea falls off (Figure 7). The reported incidence of dysentery diarrhoea also shows seasonal peaks in the hot and early rainy season, and this category should be more specific to shigellosis and campylobacteriosis (Figure 8). Since most health centres do not have the facilities to identify pathogens and the presence of blood or mucus in stools may not always be thoroughly checked, then it is thought that many cases of dysentery will be misclassified as acute diarrhoea.

The seasonal peaks of diarrhoea cannot be explained by the outbreak of repeated epidemics originating from a common source, for two reasons. First, there are no obvious mechanisms by which diarrhoeal disease could spread so quickly and consistently over such a vast area, given that the peaks and troughs usually occur on the same months in the different changwats. In the cases where epidemics of cholera and shigellosis have been closely studied by the MOPH, the spread between changwats, or even amphurs, has never been instantaneous. Second, case-control studies comparing pathogens from patients with and without diarrhoea have found that most agents are still well represented in controls, with the notable exceptions of rotavirus and Shigella. Moreover, in one study 57% of Peace Corps Volunteers developed travellers’ diarrhoea during their first five weeks with infections of ETEC (26%), Shigella (13%), Campylobacter and Salmonella (3%). It is therefore more likely that the agents causing diarrhoeal disease are endemic in the population and that seasonal changes affect their rate of survival and transmission.

Rain has often been proposed as a major factor in the spread of diarrhoeal disease. However, the relationship between acute diarrhoea and rainfall is not altogether clear in these charts. There is no evidence to suggest that rainfall has a direct affect, but it may be expected to have an impact on certain factors which affect faeco-oral routes. For example, rainfall may be influential as most enteric bacteria survive longer in a moist environment and can be physically moved with water. It may also indirectly affect the spread of disease by changing factors such as water use and availability. This has particular relevance to northeast Thailand as rainwater collection by rural households provides an important water source for drinking and other domestic uses.

Traditionally villagers rely on rainwater in the rainy season and groundwater in the dry season. A popular improvement to rainwater collection has been the introduction of large rainjars and by 1989, 53% of households in Khon Kaen province had a water storage capacity >4000 L. These jars are well protected from water handling due to their size and provision of a tap. Overall, the bacteriological quality of water from rainjars is slightly more contaminated early in the rainy season, it is not thought that this is responsible for the increase in diarrhoeal disease as it still provides cleaner drinking water than alternative sources.

In an associated study, faecal contamination of water stored within the domestic environment (apart from rainjars) was found to be much greater than water sources. Practices within the household led to a high risk of cross-contamination of faecal bacteria to prepared food and utensils. If the practices leading to cross-contamination are assumed constant then high humidity may well increase the chances of bacterial survival. In this study a positive correlation was found between E. coli found on fingertips and daily humidity. Interestingly there appears to be a similar relationship between weekly diarrhoeal disease and humidity for the peak of diarrhoea but only during the early part of the rainy season (May–June) (Figure 9).

The steep reduction in diarrhoea around the middle of the wet season may be indirectly affected by the rains. Rainwater is not only used for drinking but also for domestic activities when available, and this should lead to an increase in the amount of water used as it is more convenient than other water sources. Studies indicate that increased water quantity may be more effective in reducing diarrhoeal disease than improvements to water quality alone. More water used for domestic activities may gradually decrease the number of bacterial pathogens available for faeco-oral transmission cumulating in a reduction in diarrhoeal disease as the effect of humidity is nullified. In addition, the rains are often sporadic early in the rainy season and therefore water quantity may improve later in this season when rainfall is more reliable.

Little is known about the relationship between the ingestion of enteric pathogens and the manifestation of disease, however the infective dose of bacterial pathogens is generally high. Studies suggest that food and food-related activities within the domestic environment may be important factors in determining the survival and even multiplication of certain bacterial pathogens. This may provide a reasonable mech-
anism for the spread of diarrhoeal disease within households but what of transmission between households? In northeast Thailand, as with many developing countries, personal interaction between householders is part of the villager's way of life. Mothers often leave infants and babies in the care of friends, neighbours and relatives and meals are commonly shared between households. Studies have also shown that ETEC and Shigella were significantly more common in neighbours and relatives of patients with diarrhoea than in people not connected with patients.

The intention of this paper is to provide background information for studies aimed at the prevention of diarrhoeal disease. The charts provide a limited and simplified presentation of what is certainly a complex phenomenon. There is no doubt that a strong seasonal pattern exists and the following are tentative explanations of the seasonal changes in the reported incidence of acute diarrhoea:

—A multitude of pathogenic agents are endemic in the population and climate selectively affects their survival in the environment.

—Certain environmental factors directly or indirectly affect the faeco-oral transmission of microorganisms.

—Seasonal changes affect the susceptibility of the host to the manifestation of disease.

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REFERENCES


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