

Diarrhoea morbidity in children in the Asaro Valley, Eastern Highlands Province, Papua New Guinea

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SUMMARY

A morbidity study of diarrhoea covering 1926 children aged less than 5 years was carried out in Goroka town and the Lowa and Asaro Census Divisions, Eastern Highlands Province between 1986 and 1989. The study involved weekly demographic surveillance of the total population and morbidity surveillance of children by lay reporters who enquired about the presence or absence on any of the preceding 8 days of a range of symptoms associated with diarrhoeal and respiratory diseases. A three-day symptom-free period was used to define distinct episodes of diarrhoea. The average number of episodes/child-year for all children in the study population was 3.0. Boys suffered a significantly higher incidence of diarrhoea under 48 months of age than girls (4.4 episodes compared to 3.6/child-year). Incidence was highest among those aged 6-17 months (5.5/child-year) with a rapid decline after age 35 months. Incidence of diarrhoea was highest in the more remote Asaro Census Division and was higher in periurban areas than in Goroka town. Incidence also varied significantly between villages, some villages experiencing up to 10 times the incidence of diarrhoea found in Goroka town. The incidence of diarrhoea was significantly higher in January than at other times of year. Duration of diarrhoea varied with age, the longest duration being an average of 4.7 days in the 12-17 months age group. In order to reduce diarrhoea morbidity, it is necessary to improve access to water, encourage improved hygiene practices and breastfeeding and warn people about the risks of sleeping with pigs.

Introduction

Diarrhoeal disease is a major cause of morbidity in children in the developing world. There are an estimated 1.5 billion episodes of diarrhoea and 3 million deaths in children under 5 years old each year (1). In 1993 the World Health Organization estimated the incidence rate in children under the age of 5 years in Papua New Guinea (PNG) to be 2.9 episodes/child/year. This was slightly higher than the average of 2.5 for the Western Pacific region (excluding China) but less than the average rates found in Africa (4.9), the Americas (3.5) or the Eastern Mediterranean Region (3.7) (2). Epidemics of dysentery were documented in the highlands of PNG as long

ago as 1944 when, with causes related to the Second World War, an epidemic began near Goroka and spread as far west as Tari (3).

A number of community-based studies which describe the epidemiology of diarrhoea have been carried out in PNG. Using fortnightly surveillance Frankel and Lehmann (4) reported the incidence rate of diarrhoea in 1982-1983 to be 0.39/child-year in children aged less than 5 years in Tari, Southern Highlands Province, with an incidence of 0.47/child-year under the age of 1 year. A study in an urban settlement of Port Moresby found that incidence rates of diarrhoea varied from 0.09/child-year in the 48-59 months age group to 1.8/child-year in the 12-17 months age group (5). A relatively

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wide range of morbidity rates is to be expected due to the wide genetic, cultural and geographic variations within PNG in addition to methodological differences between studies, particularly with respect to frequency of surveillance and definition of diarrhoea.

The study reported here was part of a broader population-based study, carried out by the Asaro Surveillance Unit (ASU) of the PNG Institute of Medical Research (PNGIMR) between 1980 and 1989 (6,7), to describe the epidemiology of diarrhoea and acute respiratory tract infections in the Asaro Valley, Eastern Highlands Province and to evaluate interventions. In this paper we describe diarrhoea morbidity in children under the age of 5 years from data collected between 1986 and 1989.

Methods

This epidemiological study of diarrhoea in children under the age of 5 years took place between November 1986 and April 1989 in Goroka town and the Lowa and Asaro Census Divisions in the Asaro Valley, located 6 degrees south of the equator. Villages within the study area are situated between 1500 and 1900 metres above sea level and within 38 kilometres of Goroka town. There is little seasonal variation in temperatures in the Asaro Valley. Diurnal temperatures usually range between 16°C and 30°C. Annual rainfall averages 2 metres and there are clear wet and dry seasons with 75% of the rain falling between November and April.

In Goroka town people live in houses made of permanent materials and usually have at least one wage earner per household. Housing is described as high, medium or low cost according to size, availability of electricity and water, and type of latrine. The sections with mainly low cost housing tend to be densely populated, with many itinerants, fewer wage earners and worse sanitation than other parts of town. In the rural areas people live in hamlets in houses made of wood and woven cane-grass with thatched roofs. The majority of the rural population are subsistence farmers who also earn cash, primarily through smallholder production of coffee, employment on plantations and marketing of garden produce.

The census units are villages, each comprising a number of hamlets of varying size.

The study took place in a random sample of villages and sections of Goroka town (6). The rural area was stratified into 5 by census division (Lowa being nearer Goroka town and hospital than Asaro) and then by village population size (<200 and 200-400 in each census division and >400 people in either census division). Each village was considered as a cluster and probability proportional sampling done according to the number of children in the village until 200 children were achieved in each stratum. In Goroka town, sections of town were assigned to high, medium or low cost housing strata and probability proportional sampling done by households such that 15% of the population in each stratum was sampled.

Weekly demographic surveillance of the total population (on average approximately 8000 people) and morbidity surveillance of children aged less than 5 years was done by lay reporters with at least primary school education. The reporters were selected after consultation with local leaders to work in their own areas (6,7). Reporters were trained both in the PNGIMR office and in the field and were supervised by nurses. People intending to reside for an extended period in the selected areas were included in the demographic surveillance and information on marriage, divorce, pregnancy, births and deaths obtained. People left the study if they moved out of the surveillance area permanently. For morbidity surveillance each reporter visited on average 6 children daily. Children born during the study period were included in the morbidity surveillance from birth. Children left the morbidity study on attaining the age of 5 years.

Household visits were made in the same order on the same day weekly. If the child was not seen this was indicated on the form and no other information collected except a record of any current hospitalization. Reasons for children not being seen included the reporters' two-week Christmas holiday, tribal fighting which resulted in population dispersal and disruption of daily life, absence from the village on the day of the reporter visit, or the death of the child. If a child was seen, a

retrospective morbidity history was taken for the interview day and the previous seven days. The mother or other close relative was asked if the child had been to any health facility in the previous week and, if so, what treatment had been received and whether the child was still ill. The reporter then asked whether cough, breathlessness, fever, measles rash, diarrhoea, bloody diarrhoea or vomiting had been present on any of the surveillance days. The presence of any of these symptoms on any day was recorded. Person-time at risk was calculated by summing the days covered by the morbidity forms, allowing for overlaps and gaps where they occurred, and excluding the days of reported diarrhoea.

If a child died, the method of 'verbal autopsy' (interview with relatives who attended to the deceased during the terminal illness) was used to determine the cause of death and, where available, supplemented with information from health services (7).

Analysis

Data were entered on microcomputer, error checks performed and data cleaned. Age was grouped into seven categories: <6 months, 6-11 months, 12-17 months, 18-23 months, 24-35 months, 36-47 months and 48-59 months.

For the present analysis the Asaro Valley has been divided into four geographical areas, in order of increasing remoteness from Goroka town: the town itself (divided into low, medium and high cost housing areas), the periurban areas (within Lowa Census Division), other villages in Lowa Census Division, and the Asaro Census Division.

One or more days of diarrhoea was regarded as a distinct episode provided it was separated from a previous episode by at least three symptom-free days. This definition has been used elsewhere (8,9) and is an appropriate choice when incidence rates are not very high in global terms (9). It was also found to be appropriate for our own dataset.

Duration of individual episodes was calculated. Children were seen on the same day each week and there is no biological

reason for the duration of an episode of diarrhoea to vary according to the day of onset. However, we found that the mean recorded duration of episodes increased three-fold over the recall period, from 1.7 days for episodes beginning on the interview day to 5.7 days for those beginning a week earlier. This difference is due to poor recall of duration of illness on weekly monitoring and to censoring of an episode because of a child's absence on the following week's visit. For example, an episode which began on the day before the visit would have been recorded as of 2 days' duration if the subsequent few days of illness after the visit were not recalled on the following week's visit or if the child were absent the following week. However, if a child had had diarrhoea for most of the week preceding a reporter visit then the longer duration of illness is likely to have been recalled. In an attempt to correct for this variation in duration of episodes according to the starting day, an adjustment proposed by Haggerty et al. (10) was calculated.

Statistical analysis

Statistical analysis was done using the software S-Plus (11). Incidence rates were analyzed using Poisson regression, with the standard errors inflated by a factor measuring excess variability (12,13). Sex, age, place of residence and month were included as covariates.

Results

1926 children took part in this morbidity study (1009 boys and 917 girls) between 1 November 1986 and 21 April 1989. Exposure varied from 5 days to 847 days per child with a total of 584,605 days of exposure in the study.

Incidence rates

Using the three-day symptom-free definition of distinct episodes there were 4595 episodes of diarrhoea during the study period. On an annual average basis, approximately 41% of children had no diarrhoea, 13% had one episode, 10% had 2 episodes and 9% had 3 episodes. 7% had more than 10 episodes. Blood in stools was reported in 5% of episodes. There were 5 deaths from diarrhoea

irrespective of any other symptoms being present, a case fatality rate of 0.11%.

Table 1 summarizes incidence rates by age and sex, Table 2 summarizes incidence rates by age and place of residence and Table 3 shows the rate ratios and 95% confidence limits from the log-linear model including sex, age, place of residence and month as covariates. The overall incidence rate of diarrhoea under 5 years of age was 3.0 episodes/child-year. Age had a highly significant effect on the incidence of diarrhoea and girls had significantly fewer episodes of diarrhoea under the age of 4 years than boys. The incidence rate of diarrhoea peaked at 5.5 episodes/child-year between 6 and 17 months of age and thereafter declined (Table 1).

Place of residence also had a highly significant effect on incidence rates with the highest incidence rate (4.1 episodes/child-year) in the Asaro Census Division and the lowest rate (1.7 episodes/child-year) in the high cost areas of Goroka town. Within Goroka town, there was no difference between diarrhoea incidence rates of children living in medium and low cost housing areas. Children in the high cost areas had consistently lower

incidence rates of diarrhoea than those in the other two areas and this difference was greatest in children aged 6-11 months; in this age group incidence in medium and low cost areas was 4.1/child-year compared to 2.3/child-year in the high cost area (Table 2).

Both the periurban area and the Asaro Census Division had incidence rates significantly higher than the incidence rate found in Goroka town overall (Table 3) although rates in the periurban area were similar to those in the medium and low cost areas of town. The incidence rate was very high (7.5 episodes/child-year) in children aged 6-17 months in the Asaro Census Division (Table 2) and was considerably higher there than elsewhere in all age groups. Significant variation was also found between the incidence rates of diarrhoea in 22 different villages, with some villages having up to 10 times the incidence found in Goroka town.

Calendar month had a smaller but significant effect on incidence rates (Table 3), with a peak in January (3.8 episodes/child-year) and another, smaller peak in July-August (3.3 episodes/child-year).

The data were re-analyzed using various

TABLE 1

INCIDENCE OF DIARRHOEA BY AGE AND SEX

Age (months)	Males			Females			Total		
	Number of episodes	Child- years	Incidence rate ^a	Number of episodes	Child- years	Incidence rate	Number of episodes	Child- years	Incidence rate
0-5	245	88.6	2.8	211	77.4	2.7	456	165.9	2.7
6-11	565	89.7	6.3	354	79.9	4.4	919	169.6	5.4
12-17	539	88.3	6.1	386	75.7	5.1	925	164.0	5.6
18-23	371	82.3	4.5	305	71.1	4.3	676	153.3	4.4
24-35	464	150.0	3.1	350	137.8	2.5	814	287.8	2.8
36-47	275	157.7	1.7	177	150.3	1.2	452	307.9	1.5
48-59	172	153.5	1.1	181	144.3	1.3	353	297.8	1.2
Total	2631	810.0	3.3	1964	736.4	2.7	4595	1546.4	3.0

^a incidence rate: number of episodes of diarrhoea/child-year

TABLE 2

INCIDENCE OF DIARRHOEA BY AGE AND PLACE OF RESIDENCE

Age (months)	High cost		Goroka town		Low cost		Periurban		Lowa CD		Asaro CD		Total	
	rate ^a	n ^b	rate	n	rate	n	rate	n	rate	n	rate	n	rate	n
0-5	1.0	7	1.3	27	1.6	18	1.8	58	2.1	60	4.4	286	2.7	456
6-11	2.3	21	4.1	83	4.1	54	3.6	113	4.5	143	7.6	505	5.4	919
12-17	4.0	45	4.3	85	4.2	38	5.0	162	4.2	126	7.4	469	5.6	925
18-23	3.0	29	4.1	77	3.7	33	4.7	144	3.1	86	5.2	307	4.4	676
24-35	1.7	30	2.3	76	0.9	15	1.9	111	2.2	116	4.2	466	2.8	814
36-47	0.8	11	1.1	41	1.4	21	1.4	82	0.8	42	2.1	255	1.5	452
48-59	0.6	10	0.7	30	1.1	22	1.0	45	1.0	52	1.6	194	1.2	353
Total	1.7	153	2.2	419	2.1	201	2.5	715	2.2	625	4.1	2482	3.0	4595

CD = Census Division

^a incidence rate: number of episodes of diarrhoea/child-year^b number of episodes**TABLE 3**

EFFECT OF SEX, AGE, PLACE OF RESIDENCE AND CALENDAR MONTH ON RATE RATIOS FOR INCIDENCE OF DIARRHOEA

Factor	Rate ratio	95% confidence limits	
Sex	Male	1.0	
	Female	0.84	0.79 0.89
Age	0-5 months	1.0	
	6-11 months	1.98	1.75 2.25
	12-17 months	2.06	1.82 2.33
	18-23 months	1.61	1.41 1.83
	24-35 months	1.03	0.91 1.17
	36-47 months	0.53	0.46 0.61
	48-59 months	0.43	0.37 0.50
	Residence	Town	1.0
	Periurban area	1.14	1.02 1.28
	Lowa Census Division	1.05	0.93 1.18
	Asaro Census Division	1.93	1.77 2.11
Month	January	1.0	
	February	0.78	0.68 0.90
	March	0.79	0.69 0.90
	April	0.71	0.61 0.82
	May	0.68	0.57 0.80
	June	0.79	0.68 0.92
	July	0.85	0.73 0.98
	August	0.84	0.73 0.97
	September	0.74	0.64 0.87
	October	0.74	0.63 0.86
	November	0.75	0.65 0.86
	December	0.59	0.50 0.70

definitions of episode. There was very little difference between the number of episodes whether one, two or three symptom-free days were used to define a new episode but there was a 13% reduction in the number of episodes using a seven-day symptom-free period. This was accompanied by some small changes in the significance of each factor but the same factors remained significant at the 5% level.

Duration of episodes

The mean duration of an episode of diarrhoea was 4.4 days, 68% of episodes lasted 4 days or less, 86% lasted 7 days or less and 12% lasted 8-14 days. The mean duration of diarrhoea episodes rose from 4.4 days in the 0-5 months age group to 4.7 days in the 12-17 months age group, with a monotonic decline thereafter, to 3.5 days in the 48-59 months age group. Duration of episodes also showed some variation by calendar month with March having the highest mean duration (5.0 days) and May and December having the lowest (4.0 days). The adjustment for differences in duration according to start day (10) made very little difference to these results.

Discussion

This study provides the most reliable data so far on incidence of childhood diarrhoea for the highlands region of PNG. Sex, age, place of residence and calendar month were all significant risk factors for diarrhoea in children. The wide variation in incidence of diarrhoea between different villages may in part be due to variations in reporting by individual reporters. However, this is unlikely to explain all of the variation since reporters were carefully supervised throughout the study, poor performance resulted in dismissal and incidence rates tended to be similar during successive reporters' employment. As explained earlier, the results for duration of diarrhoea episodes should be treated with caution in view of the problems of censoring and recall in weekly surveillance.

The incidence rates of diarrhoea reported in this study are higher than the rates from other population-based studies in PNG (4,5) but low compared to rates commonly found in Africa (2,8,10). Differences in rates may be due to

differences between the populations studied, to differences in the frequency of monitoring or to the use of different definitions of diarrhoea. In our study more episodes were recorded than in the study in Tari, Southern Highlands Province (4), perhaps because a three-day rather than seven-day symptom-free period was used to define distinct episodes, and because weekly rather than fortnightly monitoring was used; even a 7-day recall period may lead to an underestimation of morbidity in the order of 30% (14). On the other hand the differences in incidence between the two areas may be real; the fact that people live in hamlets in the Asaro Valley rather than in scattered homesteads as in Tari may contribute to higher transmission rates of enteric pathogens and hence higher incidence of diarrhoea.

In the study which took place in a settlement of Port Moresby (5), monitoring was done every alternate day and diarrhoea was defined as 'three or more watery stools on one day...preceded by a diarrhoea-free period of at least three days'. The specification of three or more watery stools rather than a definition based on any history of diarrhoea which was used in our study may be one reason why the estimated incidence of diarrhoea was lower in Port Moresby than in a similar environment in the low cost area of Goroka town. Twice-weekly surveillance is now generally considered optimal for investigations of diarrhoea morbidity but is both costly and intrusive over an extended period (10,15).

The incidence of diarrhoea peaked in January. During the New Year holiday period, people travel within rural areas and between urban centres and rural areas, and many traditional feasts with 'mumus' (food cooked in an earth oven) are held. Large feasts have been associated with outbreaks of diarrhoea and may contribute to the increase in diarrhoea at this time of the year (16). Another peak occurred in July and August. This is the dry season in the Asaro Valley when scarcity of water may result in lower standards of hygiene and hence higher transmission of enteric pathogens.

Within Goroka town, children in the high cost housing section suffered less diarrhoea than children in low cost or medium cost

housing sections, no doubt related to the better sanitary conditions and lower population density in high cost areas. Incidence rates in the periurban areas and Lowa Census Division were similar to those in medium and low cost housing areas of town. Installation of adequate water supplies in the poorer parts of town, periurban and rural areas is likely to reduce diarrhoea morbidity irrespective of socioeconomic status (5).

The Asaro Census Division suffered by far the greatest incidence of diarrhoea at 4.1 episodes/child-year. Overall mortality rates are also much higher in this census division than elsewhere in the study area (7). There are a number of likely reasons for the greater incidence of diarrhoea in this area. Pig ownership is more common in the Asaro Census Division than in the other areas (16). Many women take great pride in their pig-raising abilities and since it is cold in the upper Asaro Valley, women often sleep with their children in small houses built for pigs in an effort to keep their pigs warm. In the Lowa Census Division many villagers are Seventh Day Adventists and are forbidden to rear pigs or eat pork. Pigs are banned from Goroka town. When we separated our data into 22 village groupings, the villages where most people were Seventh Day Adventists had among the lowest incidence of diarrhoea. In contrast, Guvunosa, one of the more remote villages in the study situated at high altitude (1900 m), had by far the highest diarrhoeal morbidity. Water has to be brought in from some distance and the source is used both for washing and by pigs. The villagers in Guvunosa keep many pigs which are allowed to wander around freely during the day. Bukenya and Nwokolo (5) have reported that pigs roaming freely in the settlements of Port Moresby were an important risk factor for diarrhoea. Sleeping with pigs was found to be the most important risk factor for diarrhoea in a behavioural study carried out in the Asaro Valley (16). In another study in the upper Asaro Valley, rotaviruses were found in pigs from village households, but they were different from the type commonly infecting rural children at the time of the study (17).

Diarrhoea remains an important cause of

morbidity among children in the highlands of PNG; between 6 and 17 months of age children suffer on average 5 to 6 episodes and at least 24 days of diarrhoea. Diarrhoea impairs the growth of children (18) and is an additional burden for mothers. In order to reduce the incidence of diarrhoea, provision of safe water as near to people's homes as possible is the most important intervention. This is of increasing importance given that typhoid is now endemic in many parts of the highlands (19). The ready availability of water should in itself encourage improved hygiene but improved hygiene practices should also be reinforced repeatedly. The construction and use of latrines must also be encouraged.

The fact that until recently breastfeeding was almost universal in PNG, often up to the age of 2 years, may be one reason why diarrhoea incidence has remained low compared to many other developing countries. However, while the Baby Feed Supplies (Control) Act of 1977 forbids the sale of feeding bottles without a doctor's prescription (and was amended in 1984 to include infant feeding cups and other feeding utensils), there is evidence to suggest that bottle-feeding is becoming more common (20). Every effort must be made to encourage and facilitate breastfeeding to prevent diarrhoea as well as other illnesses. People need to be informed of the benefits of breastfeeding and dangers of bottle-feeding, particularly since there is a tendency to pass bottles on from one mother to another. In many parts of PNG adoption is common and doctors and nurses should be encouraged to assist in inducing lactation for women who have adopted children.

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