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Defining Episodes of Diarrhoea: Results from a Three-country Study in Sub-Saharan Africa

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ABSTRACT

The study was conducted to assess the effect of definition of episode on diarrhoeal morbidity and to develop a means of adjusting estimates of morbidity for the definition of episode used. This paper reports on a cohort study of 374 children, aged 9-32 months, in three African countries, which recorded frequency and consistency of stool over a seven-month period. Different definitions of episode were applied to these data to assess their effect on annualized diarrhoeal morbidity. Adjustment factors were then derived that corrected morbidity for non-standard definitions of episode. Applying non-standard definitions of episode gave estimates of an annualized number of episodes between 38% and 137% of the internationally-accepted definition. Researchers should be encouraged to use the standard definition of episode of diarrhoea and to use appropriate field protocols. Where this is not possible, correction factors should be applied, particularly where estimates of diarrhoeal morbidity are pooled in systematic reviews.

***Key words*:** Diarrhoea; Morbidity; Definitions; Epidemiology; Sub-Saharan Africa

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INTRODUCTION

Diarrhoea accounted for an estimated 1.6 million deaths globally among children aged less than five years and was the third most important cause of death in 2002 (1). Accurate quantification of diarrhoeal morbidity is important in understanding the global burden of disease, so that research effort and resources can be targeted towards the most widespread diseases. In this regard, episodes have been used for measuring the trends in morbidity, regional burdens of disease, and the cost-effectiveness of different interventions.

Studies on diarrhoea often define an episode differently, making inter-study comparison of morbidity and estimation of burden of disease difficult. The most widely-accepted standard definition of a diarrhoea-day is one where a subject experiences three or more loose or watery stools in 24 hours or any number of loose or watery bloody stools (2). In identifying diarrhoea-days, any standard definition must also specify the criteria for defining the end of an episode, particularly where individuals suffer sporadic bouts of diarrhoea over time. Typically, an individual must experience a minimum number of consecutive diarrhoea-free days between episodes. Three consecutive diarrhoea-free days has been proposed as an international standard (2).

A recent review drew on 27 studies to estimate global diarrhoeal morbidity (4). As noted by its authors, the studies identified through the review defined episodes of diarrhoea in different ways with unknown consequences for regional estimates of morbidity. In some studies in this review, rather than using consistency and frequency of stool, a local language was used for identifying diarrhoea-days. For example, a Zimbabwean study used the Shona word 'manyoka' to identify days on which diarrhoea occurred (3). The effect of definition of episode on estimates of morbidity has been assessed using artificially-generated data (5) and using several datasets from the field (2,6,7). No studies have so far examined the effect of definition of episode on estimates of morbidity in sub-Saharan Africa.

This paper addresses this definitional problem by analyzing data on diarrhoea from three sub-Saharan African countries. Data on diarrhoea were gathered using a pictorial diarrhoea-diary, which recorded daily frequency and consistency of stool. The diary enables the calculation of the number of episodes of diarrhoea according to any definition and not solely the international standard definition. We were, thus, able to compare the effects of different definitions of diarrhoea on an estimated annual number of episodes. Based on this analysis, we developed a method for standardizing definitions of diarrhoea.

MATERIALS AND METHODS

Study areas

The study areas are located in the Mutale municipality of Vhembe district, Limpopo province in South Africa, in Kirinyaga district of Central province, Kenya, and Zaka district in Masvingo province in Zimbabwe. The South African municipality of Mutale had a population of 69,313 in 2001, of whom 40% have no access to sanitation (8). The majority (53%) of the population use public standpipes with a further 14% using rivers, dams, and springs as sources of water. The Zaka district in Zimbabwe has a population of 184,814 (9). As of 1992 (more recent 2002 census data are not yet available), 45% of the population in the district had no access to protected water sources, and 70% had no access to any type of sanitation facility (10). The Kirinyaga district in Kenya had a population of 553,123 in 1999. Within the Central province, 45% of the population had no access to protected sources of water in 1999 (11). The Zimbabwean and South African study areas have two distinct seasons: a prolonged dry spell from May to October and a wet season from November to April.

Data collection

In each study area, we identified the five health centres with the highest rates of childhood diarrhoea. We then asked clinic staff to identify the villages with the highest and the lowest prevalence of diarrhoea in their catchments and selected these for study. In each of these villages, we randomly selected 12 households, plus 2 additional households as replacements. Households selected had at least one child aged 12-24 months, the age cohort most prone to diarrhoea. The nature and purpose of the study were explained to participants, and consent was obtained from the head of each household. In South Africa, 14 extra households, unused as replacements, were retained in the study. The sample size comprised 374 children (Kenya: 120; South Africa 134; Zimbabwe: 120).

To overcome the problems described above in defining diarrhoea, we developed a 'smiley' diary to identify episodes of diarrhoea (12). The diary can be used where adults have only limited formal education. The diary forms part of a bigger study of water contamination between source and final point-of-use in the home. The study investigated the linkages between point-of-use water quality and diarrhoea among young children, as measured using the diary (13). Adult caregivers (mostly women) were asked to record episodes of diarrhoea among children whom they cared for using the diary over approximately 30 weeks. In Zimbabwe, monitoring of diarrhoea took place from November 2002 to June 2003 and in South Africa from August 2002 to April 2003. Because of possible disruption in fieldwork associated with the Kenyan elections of December 2002, monitoring in Kenya took place slightly later, from February to September 2003. As a consequence, the children monitored in Kenya were slightly older than those in the other two study countries.

The diary consists of a table with a separate row for each day of the week (Fig. 1). One smiley face and five sad faces were drawn on the diary next to each day. If all the child's stools were normal in a particular day, the caregiver marked the happy face. Every time the child passed a loose or watery stool, the caregiver marked one of the sad faces corresponding to that particular day. A loose or watery stool was defined as one that would take the shape of a container. The caregiver also marked a box on the right of the diary each day a child passed blood or mucus in its stools. A different sheet was used for recording episodes of diarrhoea each week.

Fig. 1. The pictorial diary used for recording frequency and consistency of stool in the study

	Normal stool	Diarrhoea				With blood and/or mucus
Monday	☺	☹	☹	☹	☹	▢
Tuesday	☺	☹	☹	☹	☹	▢
Wednesday	☺	☹	☹	☹	☹	▢
Thursday	☺	☹	☹	☹	☹	▢
Friday	☺	☹	☹	☹	☹	▢
Saturday	☺	☹	☹	☹	☹	▢
Sunday	☺	☹	☹	☹	☹	▢

At the start of the monitoring exercise, a field worker explained the diary to the women participating in the study. At the end of each week, a field worker visited the household to collect the sheets, confirm their content verbally, and check for any problems. The field workers were typically respected members of the community, such as Village Health Workers, in Zimbabwe. A project researcher collected and checked the sheets at the end of every month, which were then computerized.

To assess the quality of information collected through the diarrhoea-diary, a trained enumerator asked a sample of child-carers about their children's diarrhoea status during the preceding 24 hours. This information was collected, using the standard definition of diarrhoea, during March 2003 in Zimbabwe, May-June 2003 in Kenya, and August-September 2002, and February-March 2003 in South Africa. The trained enumerator was a different individual to the person responsible for the diary, and this information was collected independently of the diary in the presence of a senior researcher. We then cross-checked this information against the entries in the diarrhoea-diary for the same period.

Data analysis

Effect of definition of episode on morbidity

Because daily frequency and consistency of stool were recorded, it was possible to calculate the number of episodes of diarrhoea experienced by each child in the study according to various definitions. Each definition varied in terms of the minimum number of loose or watery stools used for defining a diarrhoea-day, in terms of inclusion or exclusion of bloody stools, and in terms of the minimum number of consecutive diarrhoea-free days that defined the end of an episode.

Since the study was primarily designed to investigate water-quality effects on health, diarrhoea was monitored for approximately seven months of the year only. Therefore, the total number of episodes experienced by each child was scaled up on a pro rata basis to give an annualized number of episodes. The mean annualized number of episodes per child was then calculated for each study area and each different definition of an episode of diarrhoea. In calculating the mean annualized number of episodes, any children for whom diary-entries were available for less than 60 days were excluded.

Adjusting for non-standard definitions

We developed a method to standardize published estimates of morbidity to take into account differences in definition of episode. Regression analysis was used for assessing how different definitional components affected morbidity. To do this, we calculated the aggregate annualized number of episodes according to the different definitions, pooling data from all countries. We then used ordinary least squares regression to predict the estimated number of episodes based on the definition used. The regression analysis examined three components of the definition: (a) the number of loose or watery stools per day, (b) whether or not bloody stools were included in the definition, and (c) the number of intervening diarrhoea-free days defining the start of a new episode.

The regression coefficients for each of these three definition components could then be used for standardizing the number of episodes on the internationally-accepted definition (2).

Evaluating the adjustment method

We tested the effectiveness of the adjustment factors. Since we had no access to a similar, independent dataset from elsewhere to test our methodology, we used village-level data from our own study to assess our approach. The adjustment factors were, therefore, derived by pooling data from all three countries but tested on each village in the study.

To do this, we calculated the average annualized number of episodes for each survey village according to the various definitions available. We standardized the village-level estimates of morbidity for differences in definition of episode based on the regression analysis described above. For each village, we then compared the number of episodes according to the standard definition with the adjusted estimates from the non-standard definitions. To make this comparison, we used the concordance correlation statistic (14). This statistic measures the agreement between two sets of measurements without assuming an underlying distribution. We also measured bias and calculated limits of agreement using the method described by Bland and Altman (15). In this context, bias would be a consistent over- or under-estimation of diarrhoea episodes by the adjustment method (15). The concordance correlation coefficient can take values between -1 and +1, with +1 indicating perfect agreement, 0 indicating no agreement, and -1 indicating systematic disagreement.

RESULTS

Patterns of morbidity

Of the original 120 children recruited to the study in each country (134 in South Africa), data on frequency and consistency of stool were available over a 60-day period or greater for 83 children in Kenya, 115 children in South Africa, and 111 children in Zimbabwe. Among children with at least 60 days' diary records, data on diarrhoea were available for an average of 126 days in Kenya, 195 days in South Africa, and 159 days in Zimbabwe. At the start of the monitoring period, the Kenyan children had a median age of 26 (range 18-32) months, the South African children had a median age of 17 (range 9-26) months, and the Zimbabwean children had a median age of 21 (range 11-26) months. Fifty-six percent of the Kenyan children were girls compared to 47% of the South African children and 50% of the Zimbabwean children.

Fisher's exact test suggested a significant correlation in Kenya and Zimbabwe between the diary results and the independently-collected information concerning childhood diarrhoea ($p<0.01$ and $n=61$ in Zimbabwe; $p<0.05$ and $n=34$ in Kenya). In South Africa, there was a weak association between the two datasets ($p=0.06$; $n=57$). There were no significant differences in the proportion of diarrhoea recorded in the diary versus the independent questionnaire survey.

Figure 2 shows the distribution of the annualized number of episodes of diarrhoea experienced by children in the three study countries. According to the standard definition, the mean number of episodes per year was 7.7 in South Africa, 7.1 in Kenya, and 18.6 in Zimbabwe.

Effect of definition of episode on morbidity

Table 1 shows how changes in the definition of episode affected the total observed number of annualized episodes in each country. Similarly, Figure 3 shows the annual number of episodes of diarrhoea per year according to the various definitions in each country. In all three countries, the definition that gave the greatest number of annual episodes of diarrhoea was two or more loose/watery stools per day or one or more loose/watery, bloody stools in a day, and a minimum of two consecutive diarrhoea-free days defining the end of an episode. The use of this definition led to an over-estimation of annual episodes of diarrhoea by 37% (averaging across all 3 countries) compared to the standard definition. The definition that produced the lowest number of annual episodes of diarrhoea was four or more loose/watery stools per day with a minimum of seven consecutive diarrhoea-free days defining the end of an episode. This definition under-estimated annual diarrhoea episodes by 62% compared to the standard definition, averaging across all three countries.

Fig. 2. Distribution of annual number of episodes of diarrhoea among children in Kenya, South Africa, and Zimbabwe based on the proposed standard definition of episode

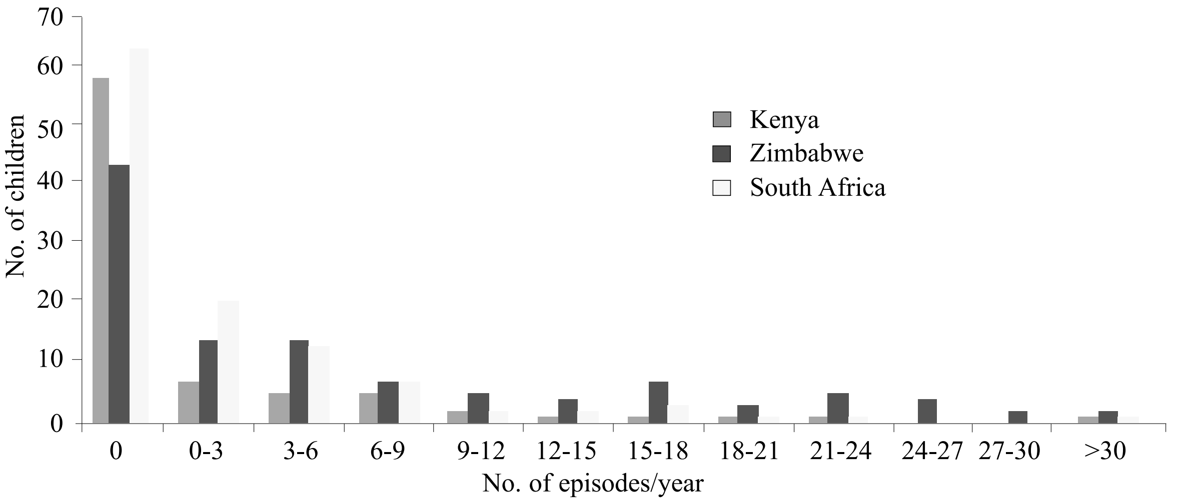


Table 1. Effect of changes in definition of episode on total annualized observed episodes by country

Episode definition used		Total no. of episodes by country		
Type of stool	No. of loose stools	South Africa (n=115)	Kenya (n=83)	Zimbabwe (n=111)
Blood/mucus included	≥2	1,018	761	2,323
Blood/mucus included*	≥3*	889	589	2,063
Blood/mucus included	≥4	797	459	1,864
Blood/mucus excluded	≥2	982	674	2,212
Blood/mucus excluded	≥3	753	448	1,627
Blood/mucus excluded	≥4	481	294	949

*Indicates the proposed standard definition

Adjusting for non-standard definitions

The effect of the three definition components on the estimated annual number of episodes is shown in Table 2, based on the pooled all-country dataset. The effect of the three definition components was as follows:

Excluding bloody stools from the definition of diarrhoea significantly reduced the estimated diarrhoeal morbidity by 2.07 episodes per year compared to the standard definition.

The estimated annual number of episodes significantly decreased as the number of stools used for defining a diarrhoea-day increased. This effect was greater when bloody stools were not included in the definition.

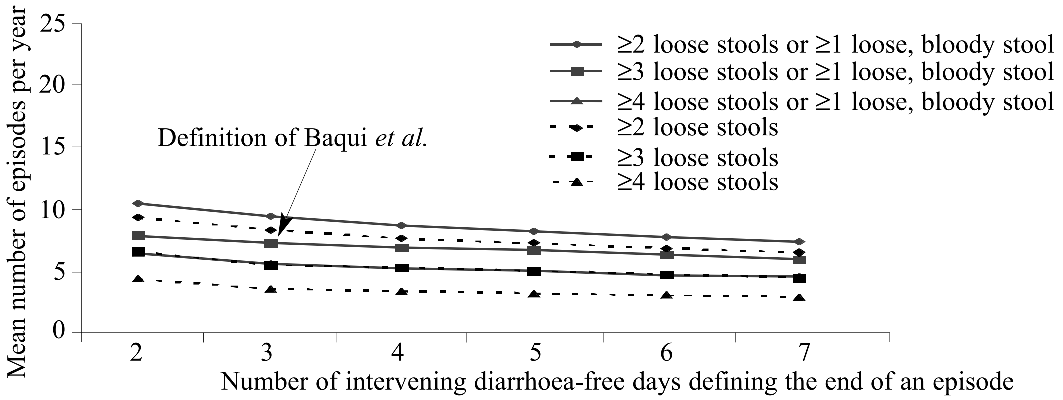
An increase in the number of intervening diarrhoea-free days that defined the end of an episode also reduced the estimated annual number of episodes.

As shown in Box 1, these regression results could then be used for adjusting estimates of morbidity to take into account the definition of episode used.

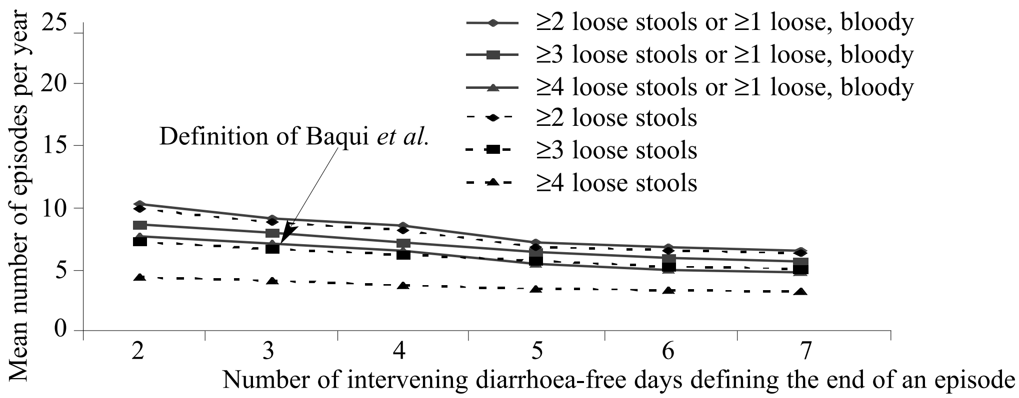
Evaluating the adjustment method

A comparison of adjusted village-level estimates of morbidity with their true (standard definition-based) values gave a concordance correlation coefficient of 0.97 (95% limits of agreement: -5.3 to 5.4 episodes per year). The unadjusted estimates of morbidity gave a lower concordance correlation coefficient of 0.95 (95% limits of agreement: -6.9 to 6.2 episodes per year), when compared with the estimates of morbidity based on the standard

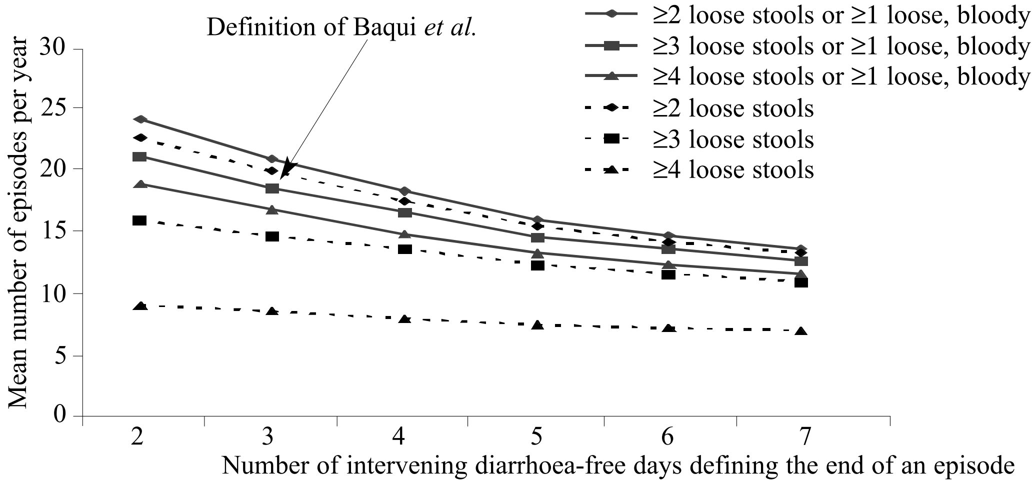
Fig. 3. Incidence of diarrhoea episodes per child per year according to different definitions for (a) Kenya (n=83), (b) South Africa (n=115), and (c) Zimbabwe (n=111). The standard definition recommended by Baqui *et al*. (1991) is indicated with the caption 'definition of Baqui *et al*.' in each graph



(a) Kenya



(b) South Africa



(c) Zimbabwe

definition. The adjusted estimates of morbidity, thus, matched the standard definition more closely than the raw, unadjusted estimates.

DISCUSSION

Patterns of morbidity

The estimates of morbidity for the Zimbabwean study site are high compared to those of previous studies in Zimbabwe, which have recorded annual episodes of 6.2 and 4.8 (16,17). Possible explanations for this high morbidity include misreporting through the pictorial diary, seasonality, and deteriorating socioeconomic conditions in this study site. Independent questioning of mothers by different interviewers provided a higher rate of morbidity that was not significantly different from that derived from the diary. This implies that the unusually high rate of incidence is not simply an artefact of misuse of diary, although this remains a possibility. Clinic-based statistics for Zimbabwe suggest that diarrhoea peaks seasonally during the late rainy season in January-March and is lowest during July-September (18). Our data may, therefore, over-estimate morbidity in Zimbabwe since the low-diarrhoea season of July-September did not form part of the period monitored here. The high morbidity may also be due to high prevalence of HIV/AIDS (19), compounded by deteriorating economic conditions in Zimbabwe.

Although the average annualized number of episodes was high in our study areas, many children remained diarrhoea-free for the whole study period. This finding is consistent with results of studies elsewhere. For example, two Indian studies found 53% and 33% respectively of Indian children suffered from no episodes of diarrhoea (20,21). Similarly, a year-long Papua New Guinean study reported 41% of young children as being diarrhoea-free (6).

Table 2. Results of regression analysis, showing effect of different components of definition of episode on the estimated annual number of episodes, based on pooled data for Zimbabwe, South Africa, and Kenya (n=36, adjusted R^2=0.94)

Definitional component	Coefficient	T-statistic	p value	Confidence limits
Number of loose/watery stools per day when bloody stools included in definition	-1.38	-7.68	0.00	-1.75,-1.01
Number of loose/watery stools per day when bloody stools excluded from definition	-2.92	-16.25	0.00	-3.28,-2.55
Number of intervening diarrhoea-free days defining the end of an episode	-0.82	-13.48	0.00	-0.94,-0.69
Exclusion of bloody stools from definition	-2.07	9.96	0.00	-2.59,-1.64
Constant	11.45	54.37	0.00	11.10,11.80

Box 1. Procedure for standardizing definition of episode for diarrhoeal morbidity

If bloody stools are not included in the definition of episode, add 2.07 to the estimated annual number of episodes.
Subtract 3 from the number of intervening diarrhoea-free days used for defining the end of an episode. Multiply the result by 0.82, and add the result to the estimated annual number of episodes.
Subtract 3 from the number of loose/watery stools used for defining a diarrhoea-day.
If bloody stools were included in the definition, multiply the result by 1.38, and add the result to the estimated annual number of episodes.
If bloody stools were not included in the definition, multiply the result by 2.92, and add the result to the estimated annual number of episodes.
The resultant figure is the adjusted annual number of episodes, standardized to the proposed international definition (2).

Effects of definition of episode

Inconsistencies in the definition of episode remain a difficulty when comparing the results of different studies on diarrhoeal morbidity. The results presented here suggest that such differences can substantially affect the estimated annualized number of episodes of diarrhoea. Here, non-standard definitions led to over-estimation of mean annual episodes per child by 37% or under-estimation by 62% compared to the proposed standard definition (2). The effect of different definitional components on estimates of morbidity is comparable with earlier studies, which suggest that the estimated number of episodes decreases as the minimum number of intervening diarrhoea-free days required to define a new episode increases (2;6).

It is possible to make an approximate correction for these definitional differences and, so, improve estimates of the global burden of diarrhoeal disease. We found that applying the correction factors to village-level averages produced annualized estimates of episode within -5.3 to +5.4 episodes (95% limits of agreement) of equivalent figures based on the internationally-accepted standard definition. Using the 'raw', uncorrected episode counts gave estimates of morbidity that were less consistent with the standard definition, as evidenced by the wider 95% limits of agreement of -6.9 to +6.2. The adjustment procedure described here, therefore, reduces but does not eliminate the effect of differences in definition of episode on estimates of morbidity.

There are weaknesses in the methodology as presented here. Our cohort study was primarily designed to investigate the inter-relationship between quality of water and health outcomes and, so, data on diarrhoea were not collected over the full calendar year. Diarrhoeal disease varies seasonally in the tropics (14) and, so, monitoring throughout the year is necessary to estimate annual morbidity. In this study, data on diarrhoea were collected in both wet and dry seasons in all three countries, which would mitigate this problem. The adjustment factors were developed using data for children, aged 12-32 months, in the sub-Saharan African region. It is unclear how far the standardization method will be applicable to other age-cohorts and regions, where the incidence of diarrhoea may follow a different pattern. These corrections may only be used with definitions that are formulated in terms of consistency and frequency of stool. Findings of studies that rely on local words to define diarrhoea cannot be adjusted using the definitional correctional factors.

The results of the analysis presented here suggest that the use of a non-standard definition of episode can substantially affect estimates of diarrhoeal morbidity. Future studies on diarrhoeal morbidity should make use of the proposed standard definition (2), which includes criteria for the end of an episode and stool frequency. In the interim, most published studies have used different definitions of an episode. These definitional differences could be reduced by using adjustment factors similar to those presented here to published estimates of morbidity. Ideally, such adjustment factors should be derived from diarrhoea-records for a whole year and drawn from a broader age-cohort. The adjustment method does not require access to the original, raw data on diarrhoea.

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