

## Association of indicators of hygiene behavior with persistent diarrhea of young children

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We examined the association between water and hygiene-related behaviors and persistent diarrhea (duration  $\geq 14$  days) among children under age three years in an indigenous rural Guatemalan community. Behavior indicators were specific aspects of the appearance of the mother, study child, other children and household that could be observed using a spot observation technique. Thirty-four percent of children had one or more episodes of persistent diarrhea during the year of study. Bivariate analyses found that a higher proportion of observations in which the anti-hygienic condition was observed was significantly associated with persistent diarrhea for 11 of 26 behavior indicators; these 11 indicators were also strongly correlated with each other. In individual logistic regression models, which included overall rate of diarrhea and other child characteristics associated with persistent diarrhea, six behavior indicators maintained significant association with persistent diarrhea: presence of toy on the ground, presence of baby bottle on the ground, the hands of the mother being dirty, presence of a fecally soiled diaper on the ground in the household compound, presence of feces in the yard, and the study child wearing a fecally soiled diaper. Three additional indicators closely approached significant association with persistent diarrhea. Excluding the three soiled diaper indicators, which might be the result rather than the cause of diarrhea, we found the six other behavior indicators to demonstrate a significant dose-response effect in increasing risk of persistent diarrhea. These findings suggest that behaviors which promote increased exposure of young children to enteric pathogens increase risk of persistent diarrhea. □ *Child diarrhea, persistent diarrhea, hygiene*

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A strong linkage between personal hygiene-related behaviors at the household level and occurrence of child diarrhea is generally assumed in international public health. Household-level behavior is believed to be important in reduction of diarrhea both in the correct utilization of population-level interventions (such as avoidance of contamination of clean water within the household) and in the adoption of individual and family-specific practices such as handwashing, breastfeeding, food hygiene, and excreta disposal within the household (1). A small number of studies have demonstrated an association between specific hygiene-related behaviors and overall risk of child diarrhea in developing communities (1). However, no study has examined the potential relationship of hygiene behaviors to persistent diarrhea among young children in such communities.

We used the data from a longitudinal prospective study of water and hygiene-related behaviors and child diarrhea in a traditional indigenous rural community of Guatemala to evaluate the association of certain household-level behaviors with persistent diarrhea. The objec-

tive of this analysis was to determine whether indicators of hygiene behavior were associated with risk of persistent diarrhea, independent of their possible association with overall risk of diarrheal illness.

### Materials and methods

The data used in this analysis were derived from a longitudinal prospective study of the association of behaviors related to water usage and hygiene with occurrence of child diarrhea in Santa Maria de Jesus, Sacatepequez, Guatemala. This is a rural indigenous community which had been the subject of a previous two-year study of persistent diarrhea. INCAP surveys performed immediately prior to that study found 82% of male heads of households to be subsistence farmers, the mean family size to be five persons, the literacy rate to be 77% among males and 39% among females, and 79% of families to live in houses with earthen floors. During the last months of the persistent diarrhea study the community installed an in-house piped water system

which included approximately half of the households in the community. Installation of piped water in a given household was by choice of the family and required payment of installation and monthly fees. This self-selection resulted in some differences between families receiving and not receiving piped water: compared to families electing piped water, those families not installing piped water were significantly less likely to have a latrine (88% vs 98%), and tended more frequently to live in houses with earthen floors (82%, vs 71%) and to have children under age three years with greater deficit of length-for-age (mean  $-1.98$  Z vs  $-1.65$  Z). There was no difference in age distribution within the 0-3-year-old age group between families electing and those refusing piped water. Most important, in the period before the study began there was virtually no difference in rates of diarrhea in 0-3-year-old children between families electing and refusing piped water (0.54 vs 0.57 episodes per child-month,  $p=0.20$ ). Most families installing water cited convenience and saving of women's time and effort, rather than reduction of illness, as the reason for electing installation.

The current study of water and hygiene behavior and diarrhea included a total of 305 families with children aged 0-30 months. Of these families, 209 were randomly selected from all families having both in-house piped water and a latrine; 36% of these families had participated in the earlier study of persistent diarrhea. The other 96 families were those without piped water who had participated in the earlier persistent diarrhea study.

Information regarding occurrence and duration of diarrhea episodes was obtained by active surveillance of study households, including routine weekly visits and visits every second day during diarrhea. Only the youngest study-age child in each household at the initiation of the study was included in surveillance to avoid duplication of risk factors by inclusion of multiple children. This resulted in comparable age distributions of children in the study families with and without piped water.

"Behavior indicators" were specific aspects of the mother, child, other household members, and the household environment that could be observed using a spot observation technique. These behavior indicators were intended to identify the product of hygiene behaviors (as visibly dirty hands reflect not having recently or adequately washed one's hands). The 26 indicators of behavior observed were based on extensive preliminary observations in the community, and on resulting assumptions regarding probable routes by which enteric organisms would reach the mouth of a young child. A few indicators, such as presence of trash in the environment, were considered general indicators of hygiene. Observed indicators included cleanliness of the mother (hands, fingernails, apron [used for multiple purposes including hand and nose wiping, cleaning children's face, etc.]), cleanliness of the study child and, separately, of other children (face, hands, fingernails, diaper),

condition of water storage receptacles (whether covered—inside and outside house), presence on the ground of articles which touch food or children's mouths (utensils, baby bottles, toys), presence of feces on ground and of fecally soiled diapers (on ground, in washing area, in living area), presence of unrestrained animals (in yard, in house), and presence of trash in the living area.

Surveillance field workers were standardized in the observational definition of each characteristic and trained using photographed examples of each indicator. Standardization in actual observation was accomplished by group sessions in which all field workers individually scored photographs of typical situations and then discussed their scoring, and through comparison and discussion of independent observations made in paired visits to households by two field workers or by a field worker with the anthropologist principal investigator. Paired observer reliability measures of actual observations in households following this training and standardization were high, between 80% and 95% for the various indicators; lowest values of paired observation reliability were for those indicators most difficult to observe, such as conditions inside the house. Following these standardization exercises, a period of testing of the final instrument and method was conducted.

Spot observations were performed by the field workers once a week for each study household. Observations were made during the first minute of the visit; workers were trained to note observations immediately or to remember the condition of the indicator observed, and to record their observations immediately after leaving the household. The observations were designed to be dichotomous; in each visit, the anti-hygienic state of each indicator (e.g. "water container uncovered") was scored as "present", "absent", or "not observed". During the one-year period of study, observations were carried out during 23 weeks in the rainy season and 22 weeks in the dry season (omitting the two transitional months between these seasons).

In the analysis, only those children with surveillance data for at least one-half of the total study period were included. For each child entering the analysis, an index for each behavior indicator was calculated by dividing the number of times the anti-hygienic behavior indicator was present by the total number of times that aspect of the household was successfully observed. These indices were categorized dichotomously based on review of their frequency distributions, with the higher index category representing a greater proportion of observations of that indicator in which the anti-hygienic condition was observed. Diarrhea surveillance data were used to identify episodes of persistent diarrhea (diarrhea lasting  $\geq 14$  days); each child was categorized as having no episode, or having  $\geq 1$  episode, of persistent diarrhea during the study period.

Bivariate analyses examined the association between categories of index of each behavior indicator for each

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child and occurrence of persistent diarrhea in that child, using non-parametric methods (chi-square test). The associations of these behavior indicators with each other and with persistent diarrhea were then examined in a Pearson correlation analysis. Behavior indicators for which high indices were found to be significantly associated with persistent diarrhea in these analyses were then examined in multivariate logistic regression models which had occurrence of persistent diarrhea in the study child as the dependent variable and which included as categorical independent variables the behavior indicator index category, overall incidence of diarrhea for each child, age and weight-for-height of each child at the beginning of the study period, and presence of piped water in the child's household.

## Results

Of the 305 children originally enrolled in the study, 280 (92%) completed over half of the surveillance and observation time of the study period and were included in this analysis. A total of 11,984 observations were completed for those children during the 45 weeks of rainy and dry season surveillance, or a mean of 43 observations per child during the study period. Ninety-five (34%) of these 280 children experienced one or more episodes of persistent diarrhea during the study period.

Bivariate analyses of the relations between the category of index of each behavior indicator and the occurrence of persistent diarrhea identified eleven behavior indicators for which higher indices of the anti-hygienic condition were significantly associated with occurrence of persistent diarrhea. These behavior indicators are identified in Table 1.

One or more of these behaviors might be confounded by other factors associated with occurrence of persistent diarrhea; for example, the association of poor hygiene of baby bottles with persistent diarrhea might be confounded by age of the child, which itself might be related to risk of persistent diarrhea. Moreover, the association of behaviors with persistent diarrhea in this analysis could simply represent their association with more diarrhea in a child. Prior to the analysis of association of behavior indicators with persistent diarrhea, multivariate analysis of the association of other potential risk factors in this population identified child age < 6 months and overall incidence of diarrhea for a child to be significantly associated with persistent diarrhea, and acute undernutrition (weight-for-length  $\leq -2.0$  SD compared to NCHS standards) to have a borderline significant association with persistent diarrhea. Child age between 6 and 18 months was significantly associated with increased total incidence of diarrhea. Therefore, we developed logistic regression models which included the behavior indicators significantly associated with persistent diarrhea in bivariate analysis, as well as these factors and the presence of in-house piped water.

Table 1. Behavior indicators significantly associated with persistent diarrhea in bivariate analyses.

Indicator
Baby bottle on ground
Feces in yard
Mother's hands dirty
Fecally soiled diaper on ground
Toy on ground
Study child in fecally soiled diaper
Water storage containers inside house uncovered
Fecally soiled diaper lying about in house
Animals loose inside house
Trash on ground in yard
Trash on ground inside house

Table 2. Association of high indices of behavior indicators with persistent diarrhea in logistic regression models including child age, incidence of diarrhea, weight-for-length at entry to study, and presence of in-house piped water.

Indicator	Odds ratio (95% c.i.)
Toy on ground	2.66 (1.06-6.64)
Baby bottle on ground	2.60 (1.42-4.77)
Mother's hands dirty	2.31 (1.12-4.79)
Feces in yard	2.28 (1.19-4.39)
Fecally soiled diaper on ground	1.93 (1.04-3.56)
Study child wearing fecally soiled diaper	1.83 (1.00-3.32)
Fecally soiled diaper in living environment	1.81 (0.99-3.30)
Trash on floor in household	1.79 (0.99-3.25)
Animals loose inside house	1.71 (0.95-3.07)

One complication in modelling the relationship between behavior indicators and persistent diarrhea was the strong correlations between most of the behavior indicators themselves; that is, families which had a high index of one indicator of anti-hygienic behavior frequently had high indices of several of the others. Paired Pearson correlation coefficients for index categories of these eleven indicators ranged from 0 to 0.52. Of the 55 possible paired correlation coefficients, 38 (69%) were significant ( $p < 0.05$ ) and 22 (40%) had coefficient values  $> 0.20$ . Including several of those variables in a single logistic regression model resulted in division of the variance among the correlated behavior indicators, possibly obscuring the detection of meaningful associations. For this reason, we developed separate logistic regression models for each of the eleven indicators identified in bivariate analysis, to examine the association of that indicator with persistent diarrhea accounting for the effects of child age, overall diarrhea incidence, nutritional status, and household water installation for each child. Of the 280 children included in the bivariate analysis, 246 had complete data on each

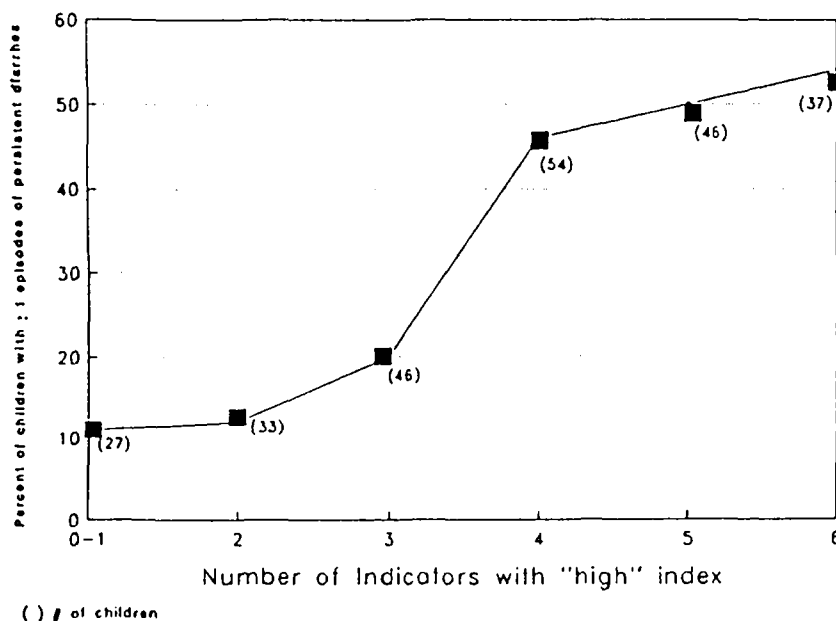


Fig. 1. Relation of a number of behavior indicators with index in "high" (anti-hygienic) category among study families and occurrence of persistent diarrhea in their 0-35-month-old children.

of the variables and could be included in the multivariate models.

The results of these analyses are presented in Table 2; six behavior indicators maintained statistically significant relationships with persistent diarrhea. Three additional indicators closely approached significance in these multiple variable models ( $p=0.055$ ,  $p=0.056$ , and  $p=0.072$ ).

To understand better the contribution to risk of these indicators, we examined their cumulative effect on risk of persistent diarrhea. In this analysis, we excluded the three "fecally soiled diaper" variables, which might be affected by reverse causality (more diarrhea resulting in more fecally soiled diapers). The effect of a family's having high indices of a given number of the other six behaviors is shown in Fig. 1. A highly significant dose-response relationship is observed, with a higher proportion of children with greater numbers of high index indicators experiencing persistent diarrhea. In a logistic regression model which included the number of high index indicators as well as the age, weight-for-length, diarrhea incidence, and water installation variables, the association of increasing number of anti-hygienic indicators with persistent diarrhea was highly significant ( $p < 0.0001$ ); each additional high index indicator increased the child's odds of having persistent diarrhea by 1.54. Categorizing these data, children whose families had three or four such indicators had an odds ratio for persistent diarrhea of 3.87 (95% CI, 1.50-9.99), compared to children in families with zero, one, or two such indicators. Children in families who had five or six

such indicators had an odds ratio of 6.31 (95% CI, 2.43-16.36) compared to the reference group.

Finally, to examine the contribution of these epidemiologic, nutritional, and behavior variables to risk of persistent diarrhea, we computed the R-square values for regression models containing these variables. A model including only the age, weight-for-length, and incidence variables had an R-square value of 0.17; most of the explanation of risk in this model derived from the strong association of overall diarrhea incidence with occurrence of persistent diarrhea (R-square = 0.15). A model including only the six behavior indicators included in the dose-response analyses had an R-square of 0.13. A complete model containing all of these epidemiologic, nutritional, and behavior variables had an R-square of 0.23, that is, explained 23% of the variance in occurrence of persistent diarrhea.

## Discussion

Our understanding of the factors which promote the occurrence of persistent diarrhea among young children in developing countries remains extremely inadequate. Several epidemiological studies, including our own, have identified a small number of such factors, including younger age at the time of diarrhea, acute malnutrition, higher overall incidence or prevalence of diarrhea, presence of blood or mucus in stools, and lack of exclusive breast-feeding, as significantly associated with persistent diarrhea (2-7). However, the overall proportion of risk attributable to these factors is fairly small: in

our epidemiologic study, the risk factors significantly associated with persistent diarrhea accounted for 17% of the variance in occurrence of persistent diarrhea. Many children in this and other study populations who do not have these risk factors also develop persistent diarrhea. The same is true of the microbiologic findings related to persistent diarrhea: in various populations invasive bacterial pathogens, various types of enteroadherent *E. coli*, *Cryptosporidium* sp., and infection by multiple pathogens have been found to be very common in persistent diarrhea, and in some cases to be significantly associated with this condition (3, 8, 10). However, many cases of persistent diarrhea occur without the presence of these pathogens, and in many prospective studies the patterns of stool isolates in acute and persistent diarrhea (especially in the acute phase of the persistent episode) are very similar (4, 11).

Given the inadequacy of this knowledge of predisposing factors for persistent diarrhea, we used our data from the community where we had studied persistent diarrhea and where we were studying the relationship between water and hygiene-related behaviors and child diarrhea in general, to evaluate the potential relationship between such behaviors and persistent diarrhea independent of their possible effect on diarrheal incidence. To provide quantitative data with which to evaluate the association between observed behaviors and diarrhea or persistent diarrhea, we used the repeated spot observation of aspects of the appearance of the mother, children, and household environment which were indicators of water and hygiene-related behaviors.

A spot observation is one that captures a moment in time in a situation or condition observed. These observations can be conducted at the beginning of a time interval, during an interval observation, or only once at the beginning of a weekly household visit or interview, as in the present study. Spot observations usually do not provide information about behaviors themselves, but about traces, products or indicators of behaviors. With this type of observation one can note the presence or absence of an object (e.g. bottle on the ground/no bottle on the ground, water container with cover/without cover) and the presence or absence of a quality as judged by the observer (e.g. "clean" versus "dirty"). Events occurring at that moment as well as the location and physical position of the subject can be observed, but were not in the present study (12, 13).

The once-a-week spot observation method proved rapid and economical, as it was conducted along with other data-gathering activities. The method was also unobtrusive, since observed subjects were unaware of the observation and it did not change the nature of the surveillance visit as perceived by the families.

As with the use of verbally administered questionnaires, this method requires careful and prolonged training and standardization to reduce the possibility of bias resulting from knowledge of a family's diarrhea

rate. After such training, paired observers' reliability measures for the indicators included in the study were quite high. The largest disagreement was for indicators inside the house, where conditions were more difficult to observe.

An important analytical concern for evaluating the association of such behavior indicators with health outcomes such as persistent diarrhea is the strong tendency we found for association between indicators of anti-hygienic behavior. In our observation, it was common to find families in which high indices of multiple indicators co-existed. In multivariate analysis a slightly greater association of one indicator with the health outcome may override the association of another closely correlated indicator to that same outcome, potentially obscuring a real significant association.

In separate models which controlled for the effect of other epidemiologic risk factors, we found that high indices of several specific indicators of hygiene behavior were associated with occurrence of persistent diarrhea. In addition, behavior indicators significantly or almost significantly associated with persistent diarrhea in these separate models had an apparent dose-response effect in increasing risk: each additional indicator in the high index category added significantly to the odds ratio for persistent diarrhea, controlling for epidemiologic and nutritional risk factors. These findings strongly suggest a real association of these indicators, and the behaviors they represent, with persistent diarrhea.

Several of these indicators—unwashed hands of the mother and the presence of toys and baby bottles found in unhygienic condition—may plausibly reflect hygiene deficits related to entry of enteric pathogens into the mouth of the child. Whether it was the use of the baby bottle or its hygiene that presented the risk identified cannot be determined by these observations. Additional indicators related to fecally soiled diapers may reflect poor attention to feces disposal or may simply reflect increased diarrhea in the children in those households. The bottle and diaper indicators are clearly age-related, so the effect of child age was controlled for in these analyses.

The association of such indicators, and by inference of the behaviors which they represent, with overall risk of child diarrhea is not surprising, and was indeed identified by our analysis of these same data (Hurtado et al. submitted for publication). A small number of other studies have confirmed what public health practitioners would expect, that in developing communities inadequacies in specific personal and domestic hygiene behaviors are associated with increased risk of child diarrhea (1, 14-17). An equally small number of well-controlled studies have demonstrated that interventions aimed at improving specific hygiene behaviors can result in reduction of rates of child diarrhea (14, 16, 17).

How inadequate hygiene-related behaviors can increase risk of persistent diarrhea deserves consideration. Indirect evidence that risk of persistent diarrhea might

be lessened by behavior change is found in the fact that three longitudinal studies, including our own, have documented reduction in the rate of persistent diarrhea during the course of longitudinal study in the absence of specific intervention (4, Black, RE [pers. comm.]). Such non-specific observer (or "Hawthorne") effect is generally believed to be attributable to modification of behavior by study subjects in response to the attention paid to the condition under study.

A connection between hygiene-related behavior and persistent diarrhea may also be suggested by the results of epidemiological and microbiological studies. Several studies have identified a higher overall rate of diarrhea in a child to be associated with risk of persistent diarrhea (3, 4). Part of the effect of hygiene behavior on persistent diarrhea might be through reduction of incidence of acute diarrhea, which we found to be one of the strongest epidemiologic risk factors for persistent diarrhea. However, controlling for the relationship of diarrhea incidence to persistent diarrhea, we found independent association of high index behavior indicators with persistent diarrhea. In addition, like Sazawal and colleagues in northern India (18), we found in our study population that independent of diarrhea incidence, a diarrhea episode which occurred within two weeks of the end of a previous episode was more likely to be persistent than episodes occurring after a longer interval (Bartlett et al., submitted for publication). Finally, persistent diarrhea has been associated with simultaneous or sequential infection by multiple enteropathogens (3, 11).

Taken together, these findings suggest that inadequacies of hygiene which result in a child being exposed more frequently or to higher doses or multiple types of enteric pathogens might result in increased risk of persistent diarrhea. This hypothesis would be consistent with the suggestion of Esrey and Feachem that interventions which reduce exposure to enteric pathogens might have greater effect in reducing severe and prolonged diarrhea than acute, self-limited diarrhea (19).

These possibilities have important implications for the control of persistent diarrhea. They suggest that interventions which reduce the frequency or dose of child exposure to enteric pathogens might result in reductions in risk of persistent diarrhea beyond the expected reduction in overall diarrhea incidence. Such interventions might include water and sanitation infrastructure improvement. Our findings suggest that such interventions should also include effective communication and education interventions focused on specific behaviors related to the probability of fecal contamination reaching children's mouths, such as caretaker handwashing before food preparation and feeding, and avoidance of non-hygienic use of baby bottles. Because of the importance of persistent diarrhea among children in developing countries, we believe that the impact of such interventions on rates of persistent diarrhea should be evaluated.

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