A Multiyear Prospective Study of the Risk Factors for and Incidence of Diarrheal Illness in a Cohort of Peace Corps Volunteers in Guatemala

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Background: Diarrheal illness is the most common medical disorder among travelers from developed to developing countries and is common among expatriate residents in developing countries.

Objective: To assess the risk factors for and incidence of diarrheal illness among Americans living in a developing country.

Design: Prospective longitudinal study.

Setting: Rural Guatemala.

Patients: Cohort of 36 Peace Corps volunteers.

Measurements: Collection of daily dietary and symptom data for more than 2 years; identification by multivariate Poisson regression analyses of risk factors for clinically defined episodes of diarrheal illness.

Results: The 36 Peace Corps volunteers in this study had 307 diarrheal episodes (median, 7 per person), which lasted a median of 4 days (range, 1 to 112) and a total of 10.1% of the 23,689 person-days in the study. The incidence density (episodes per person-year) was 4.7 for the study as a whole, 6.1 for the first 6-month period, 5.2 for the second 6-month period, and 3.6 thereafter. Statistically significant risk factors for diarrheal illness included drinking water whose source (for example, the tap) and, therefore, quality, was unknown to the person; eating food prepared by a Guatemalan friend or family; eating food at a small, working-class restaurant; eating fruit peeled by someone other than a Peace Corps volunteer; drinking an iced beverage; and eating ice cream, ice milk, or flavored ices. The relative risks comparing the presence of these exposures during the first 6-month period overseas with their absence during the second year of residence ranged from 1.90 to 2.67, and the summary attributable risk percentage (that is, the percentage of diarrheal episodes that could be ascribed to the exposures) was 75.4%. Exposures generally were riskier if they occurred during travel elsewhere in Guatemala rather than in the person’s usual work area.

Conclusions: Diarrheal illness of mild-to-moderate severity continued to occur throughout Peace Corps service but decreased in incidence as length of stay increased. Various dietary behaviors increased the risk for diarrheal illness, which suggests that avoidance of potentially risky foods and beverages is beneficial.

Diarrheal illness is the most common medical disorder among travelers from developed to developing nations (1, 2). It also is common among expatriate residents in developing countries (3–5). To prevent diarrheal illness, travelers and expatriates are urged to follow various dietary recommendations (for example, “boil it, cook it, peel it, or forget it”). However, the benefits of following such recommendations have been questioned. Several retrospective studies have shown that such practices are not protective or are associated with increased risk for diarrheal illness (6–11). On the other hand, a study in which dietary data were collected during the first few days of travel did find that the incidence of diarrheal illness increased along with the number of certain types of dietary behaviors (12). In addition, some retrospective and short prospective studies have shown that the location where food was eaten or bought was important, although the studies varied in their reports of which locations (for example, street vendors) were risky (4, 13–17).

To assess the risk factors for and the incidence of diarrheal illness among Americans living in a developing country and to revisit the issue of the usefulness of traditional dietary recommendations, we conducted a prospective longitudinal study of a cohort of Peace Corps volunteers in rural Guatemala. Participants recorded daily dietary and symptom data throughout their stay of more than 2 years abroad. To our knowledge, no other study has monitored expatriates so closely and for so long about the risk factors for and incidence of diarrheal illness.

Methods

Study Participants

In October 1991, we recruited participants among a group of Peace Corps volunteers en route to Guatemala. Participants provided informed consent, and the study was approved by the institutional review board of the Centers for Disease Control and Prevention. Participants contributed person-days to the study from the time of their arrival in
Definitions

We classified person-days as belonging to diarrheal or wellness episodes. To capture various patterns of illness that can result from infectious gastroenteritides, we used a multicomponent definition of a diarrheal episode. Given that participants had multiple episodes, we established criteria for their beginning and end, striving to minimize the likelihood of classifying relapses as new episodes and to maximize the likelihood that participants truly were well and behaved accordingly during the exposure period for each episode.

A participant was considered to have had a diarrheal or wellness episode if they had one row per day of the month, columns for specific exposures and symptoms the participants had had, and space for comments. Exposures were grouped in sections, as shown in Table 1. Participants provided additional information on beginning- and close-of-service questionnaires.

Data Collection

Participants spent an average of 1 to 2 minutes per day recording data on a structured log, which had one row per day of the month, columns for placing a maximum of one checkmark per day by the participant, and space for comments. Exposures were grouped in sections, as shown in Table 1. Participants provided additional information on beginning- and close-of-service questionnaires.

Table 1. Exposure Data and Univariate Analyses of Risk Factors for Diarrheal Illness among Peace Corps Volunteers in Guatemala*

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Days with Exposure†‡</th>
<th>Persons with Exposure§</th>
<th>Incidence of Diarrheal Illness (Diarrheal Episodes/Person-Weeks)</th>
<th>Relative Risk for Diarrheal Illness (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water sources§§</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown source</td>
<td>1690 (7.1)</td>
<td>36 (100)</td>
<td>105/584 (17.7)</td>
<td>202/1927 (10.5)</td>
</tr>
<tr>
<td>Tap</td>
<td>652 (2.8)</td>
<td>24 (66.7)</td>
<td>34/194 (17.5)</td>
<td>273/2327 (11.7)</td>
</tr>
<tr>
<td>Well</td>
<td>174 (0.7)</td>
<td>16 (44.4)</td>
<td>3/51 (5.9)</td>
<td>304/2470 (12.3)</td>
</tr>
<tr>
<td>Bottled (uncarbonated)</td>
<td>68 (0.3)</td>
<td>10 (27.8)</td>
<td>3/22 (13.6)</td>
<td>304/2499 (12.2)</td>
</tr>
<tr>
<td>River/pond/flake</td>
<td>22 (0.9)</td>
<td>6 (16.7)</td>
<td>1/14 (7.1)</td>
<td>306/2507 (12.2)</td>
</tr>
<tr>
<td>Rain</td>
<td>13 (0.05)</td>
<td>3 (8.3)</td>
<td>1/33 (3.0)</td>
<td>306/2518 (12.2)</td>
</tr>
<tr>
<td>Food sources**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guatemalan friend/family</td>
<td>6759 (28.5)</td>
<td>36 (100)</td>
<td>220/1541 (14.3)</td>
<td>87/980 (8.9)</td>
</tr>
<tr>
<td>Hotel/restaurant/bar</td>
<td>6592 (27.8)</td>
<td>36 (100)</td>
<td>219/1800 (12.2)</td>
<td>88/721 (12.2)</td>
</tr>
<tr>
<td>Comedor††</td>
<td>4306 (18.2)</td>
<td>35 (97.2)</td>
<td>152/1777 (12.9)</td>
<td>155/1344 (11.5)</td>
</tr>
<tr>
<td>Tienda‡‡</td>
<td>1012 (4.3)</td>
<td>32 (88.9)</td>
<td>41/317 (12.9)</td>
<td>266/2204 (12.1)</td>
</tr>
<tr>
<td>Street vendor</td>
<td>940 (4.0)</td>
<td>31 (86.1)</td>
<td>66/435 (15.2)</td>
<td>241/2086 (11.6)</td>
</tr>
<tr>
<td>Specific types of dietary exposures§§</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated water used to brush teeth¶¶</td>
<td>3105 (13.1)</td>
<td>26 (72.2)</td>
<td>85/461 (18.4)</td>
<td>222/2060 (10.8)</td>
</tr>
<tr>
<td>Raw vegetable/salad</td>
<td>2000 (8.4)</td>
<td>36 (100)</td>
<td>100/755 (13.2)</td>
<td>207/1766 (11.7)</td>
</tr>
<tr>
<td>Fruit peeled by non–Peace Corps volunteer**</td>
<td>1349 (5.7)</td>
<td>33 (91.7)</td>
<td>75/561 (13.4)</td>
<td>232/1960 (11.8)</td>
</tr>
<tr>
<td>Iced beverage</td>
<td>1124 (4.7)</td>
<td>33 (91.7)</td>
<td>72/402 (17.9)</td>
<td>252/2119 (11.1)</td>
</tr>
<tr>
<td>Pure fruit juice**</td>
<td>770 (3.3)</td>
<td>32 (88.9)</td>
<td>45/331 (13.6)</td>
<td>262/2190 (12.0)</td>
</tr>
<tr>
<td>Unpeeled fruit</td>
<td>672 (2.8)</td>
<td>33 (91.7)</td>
<td>40/301 (13.3)</td>
<td>267/2220 (12.0)</td>
</tr>
<tr>
<td>Raw milk</td>
<td>66 (0.3)</td>
<td>18 (50.0)</td>
<td>4/37 (10.8)</td>
<td>303/2484 (12.2)</td>
</tr>
<tr>
<td>Ice cream</td>
<td></td>
<td></td>
<td>41 (0.2)</td>
<td>13 (31.7)</td>
</tr>
<tr>
<td>Persons and animals¶¶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person with diarrhea</td>
<td>352 (1.5)</td>
<td>23 (63.9)</td>
<td>20/119 (16.8)</td>
<td>287/2402 (11.9)</td>
</tr>
<tr>
<td>Livestock with diarrhea</td>
<td>434 (1.8)</td>
<td>13 (36.1)</td>
<td>7/94 (7.4)</td>
<td>300/2427 (12.4)</td>
</tr>
<tr>
<td>Contact with manure</td>
<td>318 (1.3)</td>
<td>22 (61.1)</td>
<td>29/129 (22.5)</td>
<td>278/2392 (11.6)</td>
</tr>
<tr>
<td>Travel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guatemala City</td>
<td>3457 (14.6)</td>
<td>36 (100)</td>
<td>141/1197 (11.8)</td>
<td>166/1324 (12.5)</td>
</tr>
<tr>
<td>Elsewhere in Guatemala</td>
<td>5794 (24.5)</td>
<td>36 (100)</td>
<td>204/1561 (13.1)</td>
<td>103/960 (10.7)</td>
</tr>
<tr>
<td>United States</td>
<td>447 (1.9)</td>
<td>20 (55.6)</td>
<td>5/67 (7.5)</td>
<td>302/2454 (12.3)</td>
</tr>
<tr>
<td>Another country</td>
<td>416 (1.8)</td>
<td>29 (80.6)</td>
<td>10/85 (11.8)</td>
<td>297/2436 (12.2)</td>
</tr>
</tbody>
</table>

* If exposure data for a particular date were missing on an otherwise-completed log, the participant was assumed not to have had the exposure on that date.
† In the second column, each exposure was counted a maximum of once per person per day. The third column specifies the number (%) of persons who ever had the exposure. (See Methods about the incidence data in the fourth and fifth columns.)
‡ Percentages are of 23 689 days.
§ Percentages are of 36 persons.
¶ Water (including beverages reconstituted with water) was considered safe if it had been boiled, bottled (either carbonated or a sanctioned brand of noncarbonated bottled water), or treated with iodine.
** Food prepared by a Peace Corps volunteer was considered safe. “Food sources” refers to the persons who prepared the food that was eaten and where it was prepared or bought.
†† A comedor is a small, working-class restaurant.
‡‡ A tienda is a small store.
§§ Participants recorded these types of exposures if they were potentially risky (for example, raw vegetables or unpeeled fruit that might not have been washed in soap and soaked in iodine, ice that might not have been made from appropriately treated water, and milk that might not have been pasteurized).
¶¶ Exposure to persons with diarrhea included living or working with, nursing, or visiting such persons. Exposure to livestock with diarrhea was not strictly defined, which limited the usefulness of the variable. Exposure to manure constituted direct contact by feet or hands.

Guatemala until their Peace Corps service ended or they withdrew from the study.

Data Collection

Participants spent an average of 1 to 2 minutes per day recording data on a structured log, which had one row per day of the month, columns for placing a maximum of one checkmark per day by specific exposures and symptoms the participants had had, and space for comments. Exposures were grouped in sections, as shown in Table 1. Participants provided additional information on beginning- and close-of-service questionnaires.
other symptoms during the same 24-hour period, or 3) six or more loose or watery stools during a 24- to 72-hour period.

The beginning of a new diarrheal episode and the end of the previous episode had to be separated by 7 or more consecutive days with at most 1 loose or watery stool per day and no other symptoms. Days with residual symptoms were included in the preceding diarrheal episode. If 7 or more symptom-free days occurred, they were included in wellness episodes, as were other days that did not otherwise meet criteria for diarrheal episodes.

**Statistical Analysis**

To identify risk factors for diarrheal illness, we compared the exposures (for example, drinking tap water) that participants had had at least once in the 7-day period of wellness (that is, the exposure period) that immediately preceded the first day of a diarrheal episode with exposures during 7-day wellness periods not otherwise associated with a diarrheal episode (that is, before every eighth day of wellness). To standardize the duration of the exposure period, we excluded “leftover” wellness periods of less than 7 days. Exposures were classified as having occurred at least once or never during the exposure period.

We calculated univariate relative risks for diarrheal illness by Poisson regression analyses. We then conducted multivariate Poisson regression analyses to model illness as a function of specific exposures and to generate summary relative risks across all participants. To account for correlated observations, given that daily data were provided, we used the GENMOD procedure and incorporated the generalized estimating equations option (SAS Institute, Inc., Cary, North Carolina). We assumed that the correlation between any two periods of exposure was the same.

We constructed separate models of the variables from each section of the log (for example, water sources) by progressively removing variables that were not associated with illness \( P > 0.10 \). We then developed a model from the section variables most strongly associated with illness. Variables from the latter model were included in a model that accounted for the amount of time to date in Guatemala. All models controlled for age and sex, and we tested for age–exposure and sex–exposure interactions.

We compared proportions by using the chi-square test and ratios by using the \( r \)-statistic. When appropriate, we used SUDAAN 7.5 software (Research Triangle Institute, Research Triangle Park, North Carolina), which accounts for correlated observations. Statistical significance was set at a \( P \) value of 0.05 or less.

**Results**

**Study Participants**

Of 65 eligible Peace Corps volunteers, 36 (55.4%) participated in the study. The 36 participants had a median age of 24 years (range, 22 to 70 years; 23 [63.9%] were <30 years), and the 29 nonparticipants had a median age of 22 years (range, 22 to 65 years). Eighteen participants (50%) and 11 nonparticipants (37.9%) were women \( P = 0.33 \). Most participants remained in the study throughout their Peace Corps service, which began in late October 1991 and typically ended in late 1993 or early 1994. Ten participants (27.8%) either left the Peace Corps early (8 after a median of 10 months) or withdrew from the study (2 after 10 or 15 months); 9 nonparticipants (31.0%) left the Peace Corps prematurely after a median of 9.5 months.

Overall, the 36 participants contributed 64.9 person-years (23 689 person-days) to the study (median, 2.2 years per person [range, 0.4 to 2.5]). The compliance rate for monthly submission of a log was 98%. Of the 26 participants (72.2%) who completed a close-of-service questionnaire, 11 (42.3%) reported that they usually completed the log daily (compared with recording data for multiple days simultaneously).

**Episodes of Diarrhea**

Participants commonly had loose or watery stools. They had at least one such stool (maximum, 20) on 9.2% of person-days \( (n = 2190) \) and at least three such stools on 3.9% of person-days \( (n = 915) \). They had 307 episodes that met the criteria for diarrheal episodes (median, 7 per person [range, 1 to 27]). The numbers of episodes that fulfilled criteria for the first, second, and third components of the definition of an episode were 232 (75.6%), 54 (17.6%), and 236 (76.9%), respectively; 26 episodes (8.5%) met criteria for all three components.

The 307 episodes lasted a median of 4 days (range, 1 to 112; 75% lasted 11 days or fewer) and a total of 10.1% of person-days \( (n = 2400) \) (Table 2). For approximately one quarter of the episodes, the duration might have been influenced by antibiotic or antidiarrheal therapy. Successive episodes were separated by a median of 33 days (range, 7 to 350 days).

The date of onset for each person’s first episode ranged from a few days to more than 6 months after arrival in Guatemala. The incidence density of new episodes was 4.7 per person-year for the study as a whole, 6.1 for the first 6-month period, 5.2 for the second 6-month period, and 3.6 thereafter. The occurrence of episodes was not markedly seasonal (Figure).
or fewer (1.57 compared with 1.15; number of episodes) than for those who had seven

† The maximum number of loose or watery stools in a 24-hour period was 20. The median number of such stools per day during diarrheal episodes was 2, although most diarrheal

per day was similar for men and women (1.41 compared with 1.03; 0.69). 5

‡ Women had this symptom significantly more often than men did. The comparisons have been adjusted for the effect of correlated observations. For women compared with men, in

‡‡ The level of risk associated with the exposures of interest during travel elsewhere in Guatemala com-

Risk Factors

Table 1 provides data about the frequency at which potentially risky exposures occurred. The overall number of such exposures recorded per person per day on the logs (counting all exposures from Table 1 except those related to travel) was 1.37 for the study participants as a group. The number per day was higher for persons younger than 30 years of age than for older persons (1.54 compared with 1.03;  0.004), for persons who had more than seven diarrheal episodes (the overall median number of episodes) than for those who had seven or fewer (1.57 compared with 1.15;  0.041), and on days when participants were elsewhere in Guatemala (not including Guatemala City) for at least part of the day rather than in their usual work area (1.87 compared with 1.03;  0.001). The number per day was similar for men and women (1.41 compared with 1.34;  0.75) and during the first and second years of the study (1.33 compared with 1.37;  0.69).

In univariate Poisson regression analyses (Table 1), the following exposures significantly increased risk for diarrheal illness: drinking water of unknown source; eating food prepared by a Guatemalan friend or family; eating food from a comedor (a small, working-class restaurant); eating fruit peeled by someone other than a Peace Corps volunteer; drinking an iced beverage; eating ice cream, ice milk, or flavored ices (subsequently referred to as ice cream); and traveling elsewhere in Guatemala. Women were at greater risk for diarrheal illness than men (relative risk, 1.59 [95% CI, 1.00 to 2.52]), whereas participants in different age groups (age < 30 years compared with ≥ 30 years) did not have significantly different levels of risk (relative risk, 1.24 [CI, 0.78 to 1.97]). Multivariate analyses showed increased risk for the same exposure variables mentioned above, with the exception of travel, which did not quite meet the criteria for inclusion in the modeling. The risk for diarrheal illness was highest during the first 6-month period of residence (Table 3). For this period, the summary attributable risk percentage for the exposures of interest (that is, the percentage of episodes that could be ascribed to these exposures) was 75.4% (Table 3).

We also constructed models to directly compare the level of risk associated with the exposures of interest during travel elsewhere in Guatemala com-

Figure. Incidence of diarrheal episodes over time among Peace Corps volunteers in Guatemala. The data for each month represent the number of episodes divided by the number of person-days in the month, multiplied by 1000. The data for October 1991 began on 27 October. The onset dates for the participants’ first diarrheal episode ranged from 29 October 1991 to 15 May 1992 (median, 4.4 weeks after arrival). The earliest, median, and latest onset dates of all 307 diarrheal episodes were 29 October 1991, 15 July 1992, and 24 January 1994. The one person who was still in the study from February through April 1994 did not have any diarrheal episodes during that period. Three of the four persons who had only one or two episodes were in the study for only 5 to 10 months.
pared with the person’s usual work area. Exposures on travel days were associated with greater risk (data not shown), with the exceptions of eating fruit peeled by someone other than a Peace Corps volunteer (not statistically significant) and eating ice cream (insufficient data for modeling).

**Discussion**

Our study had two main conclusions. First, diarrheal illness of mild-to-moderate severity was common among Peace Corps volunteers and continued to occur but decreased in incidence as length of stay increased. Second, various dietary behaviors increased the risk for diarrheal illness. Our confidence in these conclusions is strong because of the prospective design of the study, which entailed documentation of daily exposure and outcome data for more than 2 years, and the analytic methods we used. The methods accounted for correlated observations and considerably increased the power to identify risk factors for diarrheal illness over the power expected for a study with 36 participants.

The conclusion that risk for diarrheal illness persisted despite a long length of stay was also noted in a recent study of expatriates in Nepal (5), in which participants were monitored less often (daily data were not collected) and for a shorter period than in our study (a mean of 7.7 months in Nepal compared with a median of 2.2 years in our study). The finding that diarrheal illness decreased as length of stay increased has also been noted previously (4, 19, 20) and might be partly due to development of immunity to the most common enteropathogens. In our study, the risk decreased even though the overall number of potentially risky exposures recorded per day on the logs was similar during the first and second years of the study. Although younger participants (age < 30 years) were not at significantly increased risk for diarrheal illness, they recorded more potentially risky exposures per day than older persons did, and previous studies have found younger age to be a significant risk factor (1, 4, 10, 11, 19).

Our conclusion that various dietary behaviors were associated with elevated risk for diarrheal illness is consistent with conventional wisdom but runs contrary to the results of some retrospective studies (4, 6–11). The risk factors we identified fell into several categories, which included exposures related to water (water of unknown source and iced beverages), exposures related to specific types of food (fruit peeled by someone other than a Peace Corps volunteer, and ice cream), and surrogate variables related to who prepared the food that was eaten and where it was prepared or bought (a Guatemalan friend or family or a comedor).

Our analyses suggest that Peace Corps volunteers had several levels of risk. On the basis of the incidence of diarrheal illness, their baseline level of risk was roughly fivefold higher than if they had been in the United States (21, 22) but was probably lower than that experienced by typical tourists (that is, short-term travelers without access to kitchens). Risk increased when volunteers ventured outside their kitchens, even if they stayed in their usual work areas; thus, they lost some control over what they consumed or some knowledge about its potential quality or felt compelled to consume potentially risky items, such as food prepared by a Guatemalan friend or family or water from an unknown source. In fact, 24 (92.3%) of 26 persons who completed a close-of-service questionnaire stated that they consumed potentially risky items in the homes of Gua-

### Table 3. Multivariate Modeling of Risk Factors for Diarrheal Illness among Peace Corps Volunteers in Guatemala by Duration of Time Spent to Date in Guatemala*

<table>
<thead>
<tr>
<th>Dietary Exposure during Previous Week†</th>
<th>&lt;6 Months of Residence</th>
<th>6 to &lt;12 Months of Residence</th>
<th>≥12 Months of Residence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relative Risk (95% CI)</td>
<td>Attributable Risk %</td>
<td>Relative Risk (95% CI)</td>
</tr>
<tr>
<td>Drank water of unknown source</td>
<td>2.38 (1.65–3.44)</td>
<td>17.73</td>
<td>2.13 (1.50–3.02)</td>
</tr>
<tr>
<td>Ate food prepared by a Guatemalan friend or family</td>
<td>2.13 (1.56–2.91)</td>
<td>42.19</td>
<td>1.90 (1.34–2.70)</td>
</tr>
<tr>
<td>Ate food from a comedor</td>
<td>1.90 (1.39–2.60)</td>
<td>27.61</td>
<td>1.70 (1.22–2.36)</td>
</tr>
<tr>
<td>Ate fruit peeled by a non-Peace Corps volunteer</td>
<td>2.12 (1.50–3.01)</td>
<td>14.21</td>
<td>1.90 (1.33–2.70)</td>
</tr>
<tr>
<td>Drank an iced beverage</td>
<td>2.03 (1.40–2.94)</td>
<td>14.08</td>
<td>1.81 (1.24–2.64)</td>
</tr>
<tr>
<td>Ate ice cream</td>
<td>2.67 (1.29–5.53)</td>
<td>2.90</td>
<td>2.39 (1.14–5.01)</td>
</tr>
<tr>
<td>Summary attributable risk</td>
<td></td>
<td>75.36</td>
<td>61.60</td>
</tr>
</tbody>
</table>

* The numbers of diarrheal episodes during the first 6-month period, the second 6-month period, and thereafter were 108, 83, and 116, respectively. The relative risks compare the presence of the exposure during the period of interest with the absence of the exposure during the second year of residence (that is, after 12 or more months in Guatemala). Compared with the referent period (sixth column), the overall risk for diarrheal illness was 1.71-fold higher during the first 6-month period (95% CI, 1.34–2.17) (second column) and 1.52-fold higher during the second 6-month period (95% CI, 1.27–1.82) (fourth column). The relative risks in the second and fourth columns were generated from the relative risks in the sixth column by assuming that the effect of time spent in Guatemala was homogeneous across all risk factors. The modeling controlled for age and sex. The 18 (50%) women in the study contributed 12,757 (53.9%) of the 23,689 person-days but 62.2% of the 307 diarrheal episodes. Attributable risk is the percentage of diarrheal episodes that could be ascribed to the exposures. The relation between the attributable risk percentages for the individual risk factors and the summary attributable risk percentage is complement multiplicative rather than additive (18).

† See Table 1 for further explanation of the exposures and see the Methods section for information on the exposure period.
temalans if doing otherwise could have been perceived as rude. The statistical significance associated with eating food prepared by a Guatemalan friend or family is reminiscent of the finding in another study that foods prepared in Mexican homes were associated with elevated risk (17). In our study, the highest level of risk generally was experienced by persons traveling outside their usual work areas.

Our study had several limitations, including the facts that the data were self-reported and that not all participants usually completed the log daily, as intended. Other limitations were that our definition of a diarrheal episode was based on clinical criteria and that all diarrheal episodes, regardless of the etiologic agent, incubation period, or mode of transmission, were combined in the analyses. The characteristics of the diarrheal episodes that we identified, including their number (\(n = 307\)), incidence (4.7 per person-year for the study as a whole and higher during the first year), and duration (median of 4 days per episode and a total of 10.1% of person-days), clearly were dependent on the definition that we used. Although we would have included many more than 307 episodes if our multicomponent definition had been less stringent, we probably ascertained more episodes than we would have if the participants had not provided daily symptom data. For example, the study in Nepal (5) showed a lower incidence of diarrheal illness (3.2 episodes per person-year) than we observed in Guatemala, perhaps in part because the former study did not collect daily data.

Another limitation of our study was that random misclassifications of exposures and outcomes (for example, misclassification of “safe” water as risky and vice versa and of diarrheal episodes as well episodes and vice versa) probably occurred and biased the results toward the null. Not surprisingly, the identified risk factors could not account for all of the observed diarrheal illness (the summary attributable risk percentage was < 100% [Table 3]). Unfortunately, collecting information about all of the potentially relevant exposures or more detailed information about the exposures listed on the log was impractical. The conclusion that ice cream was a risk factor should be considered only suggestive because the information was not collected systematically (Table 1).

Another limitation is the potential lack of generalizability of our findings. Although Peace Corps volunteers who were willing to participate in a study that entailed completing a daily log probably were not representative of all eligible persons, our efforts to encourage enrollment, compliance, espirit de corps, and the conviction that the study had scientific merit resulted in an unexpectedly high rate of faithful participation. Even so, Peace Corps volunteers are distinguishable from other U.S. expatriates and travelers by the nature and duration of their overseas stay; their relatively young age, good health, and desire to be immersed in the local culture; and by the potential tempering effect of periodic instruction (unrelated to the study) from Peace Corps medical staff about preventive measures for diarrhea. In general, the finding that both water- and food-related exposures were risk factors probably is more important than the specifics of which exposures were significant in the analyses and the levels of risk; the specifics could vary in different studies.

In summary, our study provided evidence that in practice, not only in principle, various types of dietary behaviors increase risk for diarrheal illness. Although we did not conduct an intervention trial per se, the findings suggest that avoidance of foods and beverages that are potentially at high risk for fecal contamination is wise and helps minimize, but does not eliminate, risk (19, 23, 24). Some persons might argue that expatriates should attempt to become infected and immune early in their overseas stays. However, this approach is not medically sound for the following reasons: It increases the likelihood of infection with a pathogen that could cause chronic or serious infection, expatriates are unlikely to become immune to all of the many enteropathogens, and the degree and duration of the protective effect from previous infection vary among the enteropathogens.

Admittedly, risk avoidance is complicated by behavioral factors, the seeming ubiquity of risk, and the difficulty or impossibility of modifying some risk factors (4, 9, 11, 12). In situations in which persons feel compelled to consume something, the best approach may be to eat small portions of the least risky items (although some organisms have low infective doses) and to add iodine (for short-term use only) or chlorine to water or water-based cold beverages. The common enteric bacteria are killed by less than 30 seconds of exposure at 5 °C to halogen averages. The common enteric bacteria are killed by less than 30 seconds of exposure at 5 °C to halogen concentrations of 4 mg/L in visibly clear water (25) and are killed even more readily at warmer temperatures; at 5 °C, the broadest efficacy against waterborne bacterial and viral pathogens is achieved by waiting at least 10 minutes (insufficient treatment for most parasites). Telephone access has improved in Guatemala, such that ill Peace Corps volunteers can now call medical staff in Guatemala City for recommendations about empiric therapy (for example, ciprofloxacin) to decrease the duration of illness. The diarrheal illness experienced by travelers and expatriates in developing countries should heighten awareness of the comparatively more severe health problems of the native populations in these countries and serve as a reminder that the long-
term solution is to develop creative, field-applicable ways to improve sanitation and living conditions.

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References