In our ever-shrinking world, widespread media coverage of infections, ranging from the severe acute respiratory syndrome (also known as SARS) and influenza in Asia to acute gastroenteritis on cruise ships and outbreaks in day-care centers in the United States, has raised public interest in contagious diseases to new heights. Our purpose in this article is to examine contagion (from the Latin, tangere, to touch) — direct human-to-human spread — of acute gastrointestinal illness, defined as a syndrome of vomiting, diarrhea, or both, that begins abruptly in otherwise healthy persons and is most often self-limited.

Unlike agents that cause contagious respiratory infections, which are largely or exclusively indigenous to humans, agents that cause acute gastrointestinal illness (Table 1) may spread from person to person or may be acquired from a common food or environmental source, often water; they may also result from exposure to animals. Food or water may serve as a primary source of contagion or may, in turn, have been contaminated by contact with an infected person or animal. Thus, the epidemiology of acute gastrointestinal illness is complex.

Different ways of gathering, analyzing, and presenting data have generated very different estimates of the frequency of acute gastrointestinal illness, leading to seemingly contradictory results. Estimates based on extrapolation from isolation of known diarrheal pathogens and the numbers of stool samples submitted for study suggest that there might be 38 million cases of acute gastrointestinal illness each year. In contrast, a carefully conducted questionnaire survey asking about acute, self-limited illness characterized by vomiting, diarrhea, or both found that about 1.05 cases occur per person per year in the United States. When this number was reduced by 25 percent on the basis of estimates that a respiratory infection is the responsible agent in about one quarter of persons with symptoms of acute gastrointestinal illness, the resulting 0.79 case per person per year translated to 211 million cases of acute gastrointestinal illness nationally in 1997, the year for which data were available.

Earlier data from the United States and questionnaire-based studies in the Netherlands and the United Kingdom yielded similar results. On the basis of reports to public health authorities and an exchange of information between the Centers for Disease Control and Prevention and a network of participating laboratories (FoodNet), there are thought to be about 76 million cases per year of foodborne infection. If this number and an additional 13 million cases of waterborne illness are subtracted, there may well be 122 million cases of acute gastrointestinal illness each year in the United States for which human-to-human transmission is responsible. As noted above, a varying proportion of foodborne and waterborne outbreaks are also ultimately attributable to human contamination.
**BACTERIAL CAUSES**

**SALMONELLA**

Because many principles of contagion with respect to enteric organisms were elucidated in studies of typhoid fever, it seems appropriate to begin our discussion of causes of acute gastrointestinal illness with Salmonella typhosa (S. enterica serotype typhi). Although physicians do not always associate this organism with a typical syndrome of acute gastrointestinal illness, some studies suggest that diarrhea predominates in the majority of cases. S. typhi is highly adapted to humans. Infection is virtually always acquired by transmission from one person to another; an inviolable rule of epidemiology is that the occurrence of a case of typhoid fever implies an epidemiologic link to another person who either is actively infected or is chronically carrying the organism and shedding it in feces. When cases result from food ingestion, individual food handlers, such as the infamous cook known as Typhoid Mary, are usually found to be responsible. An infection from drinking contaminated water can also usually be traced to one or more infected persons whose excreta have entered the water supply.

The current rarity of typhoid fever in the United States reflects good hygiene, lack of crowding, and high public health standards for home and industrial sewage. During the late 1990s, a breakdown of the public health infrastructure in the former Soviet Union led to a cessation of chlorination, the rating of water lines with the use of substandard pipe fittings, and the crossing of these fittings by sewage lines, which culminated in an outbreak of 10,000 cases of typhoid fever.

The likelihood of direct contagion depends on the number of organisms in feces or contaminated foods, their ability to survive, replicate, or both, and the infectivity of the species and the specific strain. Chronic carriers of S. typhi have 10⁶ to 10⁹ colony-forming units (CFU) per gram of feces or more in their feces. In experimental studies, ingestion of 10³ CFU of the Quailes strain of S. typhi was not infectious in volunteers, whereas nearly 50 percent of volunteers were infected by ingesting 10⁶ or 10⁷ CFU, and 96 percent were infected by ingesting 10⁸ or more CFU. The results of these experimental studies indicate that a large inoculum is infective. However, infection in the real world will depend on the infectivity of the strain studied. In nature, such strains are almost certainly heterogeneous, as has been shown for other enteric pathogens.

The early implications of the watchwords “fingers, food, and flies,” and the frequent spread from patients to nurses and physicians in the era before antibiotics, are consistent, at least in some instances of natural infection, with low-inoculum contagion, under the assumption that large numbers of organisms would not be transmitted in these situations. Infections with most other types of salmonella, except for S. paratyphi, derive from environmental sources, principally poultry and livestock. Despite the frequency with which these organisms cause acute gastrointestinal illness, there are remarkably few documented examples of person-to-person spread. An outbreak in a day-care facility was associated with an uncertain number of secondary cases, and long-term surveillance of 54 permanent carriers of nontyphoidal salmonella identified 10 instances of transmitted infection. On the basis of epidemiologic studies, the infective dose of nontyphoidal salmonella is thought to be small, not exceeding 100 CFU.

**SHIGELLA**

Like S. typhi, shigella has no reservoir in nature and spreads from person to person (usually child to child) through ingestion of contaminated food or water.

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**Table 1. Agents That Commonly Cause Acute Gastrointestinal Illness.**

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Viruses</th>
<th>Protozoa</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella</td>
<td>Calicivirus (Norwalk-like and related viruses)</td>
<td>Astrovirus</td>
<td>Cryptosporidium</td>
</tr>
<tr>
<td>Shigella</td>
<td>Rotavirus</td>
<td>Giardia</td>
<td>Entamoeba histolytica</td>
</tr>
<tr>
<td>Campylobacter</td>
<td>Adenovirus types 40 and 41</td>
<td>Protozoa</td>
<td></td>
</tr>
<tr>
<td>Escherichia coli O157:H7</td>
<td>Astrovirus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clostridium difficile</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† Symptomatic disease usually occurs only in infants or very young children. These organisms commonly cause acute gastrointestinal infection in otherwise healthy children and adults in developed countries. The frequency of infection is similar among such countries — for example, the United States, United Kingdom, France, and Argentina.
child) after direct contact or the ingestion of contaminated food. Shigellosis is highly contagious; as few as 200 CFU can cause infection, \(^{23}\) and the role of a small inoculum is supported by early observations, which emphasized spread by casual contact and insect vectors. \(^{24}\) The high level of contagiousness of shigellosis may be inferred from the large number of secondary cases that follow a documented outbreak; persons who have varying degrees of contact with infected patients are likely, themselves, to become infected. \(^{25}\) A very young child is the usual source. \(^{26}\)

Not surprisingly, shigella readily spreads within families, \(^{24}\) in custodial institutions, \(^{27}\) and within and among children’s day-care centers. \(^{28,29}\) Day-care centers provide remarkable natural settings in which contagion in acute gastrointestinal illness can be studied \(^{28}\) (Table 2). In these settings, shigellosis (Tables 1 and 2) may affect from one third to two thirds of children, \(^{30}\) with severe diarrhea increasing the likelihood of contagion, reflecting high fecal counts of bacteria and increased chances of soiling. \(^{26}\) At least one additional case of shigellosis is recognized in the families of about 25 percent of infected children. \(^{28}\) The current widespread use of medications that reduce gastric acidity (which normally eradicates salmonella and shigella) probably increases the risk of spread \(^{14}\) to parents of infected children or to adults who work in day-care centers.

**Campylobacter**

The epidemiology of infection due to campylobacter, perhaps now the most common bacterial cause of acute gastrointestinal illness, \(^{31,32}\) is similar to that of nontyphoidal salmonella. Most infections are traced to poultry, meat, dairy products, or contaminated water. \(^{33}\) Although fewer than 1000 CFU may cause infection, \(^{16}\) massive foodborne outbreaks are not often recognized, in part because this organism does not replicate in food \(^{34}\) and in part because ingestion even of large numbers of organisms may cause symptoms in only a small proportion of subjects. \(^{16}\) Contagion within the home has been described occasionally, \(^{35-37}\) and in one household, an infant was infected with the same strain that caused diarrhea in a newly acquired puppy. \(^{38}\) As with nontyphoidal salmonella, the paucity of descriptions of human-to-human spread may reflect the difficulty of studying organisms that are present in so many food sources. Infection by campylobacter, \(^{39}\) as well as by *S. typhi* \(^{40}\) and shigella, \(^{41}\) has been shown to be contagious among homosexual men.

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**Table 2. Factors That May Contribute to Contagion of Acute Gastrointestinal Illnesses within Day-Care Centers.**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of one or more cases of acute gastrointestinal illness</td>
<td></td>
</tr>
<tr>
<td>Lack of gloving or handwashing during or after diaper changes or helping at toilet</td>
<td></td>
</tr>
<tr>
<td>Lack of policy to isolate or send home children with acute gastrointestinal illness</td>
<td></td>
</tr>
<tr>
<td>Common area for diaper changing</td>
<td></td>
</tr>
<tr>
<td>Larger groups of children</td>
<td></td>
</tr>
<tr>
<td>Carpeted flooring</td>
<td></td>
</tr>
<tr>
<td>Shared toys and classroom objects</td>
<td></td>
</tr>
</tbody>
</table>

* These factors are discussed in Pickering et al. \(^{30}\)

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**Escherichia coli O157:H7**

Transmission of *Escherichia coli* O157:H7 occurs primarily through the consumption of contaminated meat, but secondary infection does occur, and a small bacterial inoculum may lead to clinical illness. For example, of 501 cases of *E. coli*–related diarrhea linked to hamburger consumption in an epidemic that occurred during 1992 and 1993, 48 infections (about 10 percent) were secondary. \(^{42}\) Person-to-person transmission occurs in day-care centers, \(^{43}\) among families, \(^{44}\) and in mental institutions \(^{45}\); an attack rate — the rate of appearance of symptoms in exposed persons — of around 20 percent has been reported. It is worth noting that this form of acute gastrointestinal infection is associated with a substantial incidence of the hemolytic–uremic syndrome, affecting up to 13 percent of young children with the infection. \(^{46}\)

**Clostridium difficile**

*Clostridium difficile* is a major cause of nosocomial colitis, generally occurring after antibiotic-induced alterations of bowel flora. \(^{47}\) Although the disease in some persons results from the proliferation of an endogenous strain, infection is clearly contagious; in hospitals, both human vectors and environmental contamination are implicated in the spread. \(^{48}\) In day-care settings, an infection in one child may be followed by the spread of *C. difficile* to 50 percent of the classmates, in nearly all of whom diarrhea then develops \(^{49}\); contagion is greatly facilitated by the ingestion of antibiotics. Caregivers may acquire *C. difficile* colitis while caring for patients who have this disease. We treated an elderly woman for acute *C. difficile* colitis; she had been caring for her husband during his bout of *C. difficile* colitis, and she had not been taking antibiotics. Her stools contained...
C. difficile toxin, and she responded to treatment with metronidazole (unpublished data).

**Viral Causes**

At least since the end of the Second World War, in developed countries, viruses have been thought to cause the vast majority of cases of acute gastrointestinal illness, whether sporadic or part of an outbreak. In the 1950s, a definitive family study by Dingle et al. found no isolates of salmonella or shigella in 77 cases of acute gastrointestinal illness; these investigators concluded that most cases were due to viruses, although, at the time, they were unable to isolate them. At that time, techniques were not available to identify campylobacter or E. coli O157:H7. The relative infrequency of bacterial acute gastrointestinal illness in developed countries was confirmed by prospective studies that identified salmonella, shigella, campylobacter, and E. coli O157:H7 each in 2 percent or less of fecal samples; these numbers have steadily declined in the past several years. In contrast, in underdeveloped nations, one of the aforementioned bacteria, vibrio, enteropathogenic E. coli, protozoa, or intestinal parasites cause the majority of cases of acute gastrointestinal illness.

In the United States, the United Kingdom, northern Europe, and Japan, caliciviruses such as the Norwalk and Sapporo viruses are the most common cause of sporadic acute gastrointestinal illness in patients of all age groups except infants and toddlers, in whom rotaviruses predominate. Adenovirus types 40 and 41 and astroviruses have also been implicated. Caliciviruses and astroviruses are more prevalent among outpatients, whereas rotavirus is a common cause of hospitalization.

Features of contagion by these agents are summarized in Table 3.

Within families, acute gastrointestinal illnesses are spread chiefly by young children, whose hygiene is not as consistently good as that of adults and who are dependent on, and therefore in intimate contact with, their parents and caregivers. As shown by Dingle et al., 20 percent of persons have symptomatic infection after exposure to a family member with acute gastrointestinal illness. The likelihood of secondary infection increases from 10 percent when symptoms are mild to 30 percent if severe vomiting and diarrhea are present, reflecting increased volumes of infective excreta that presumably contain higher concentrations of infective particles.

**Caliciviruses**

Caliciviruses, of which Norwalk-like viruses are the prototype, cause more than 90 percent of outbreaks of acute gastrointestinal illness in the United States and account for about 23 million cases of diarrheal disease per year, according to the pathogen-associated method of calculation. As already noted, if the same percentages are applied to cases of acute gastrointestinal illness identified by questionnaire, the incidence of calicivirus-induced infection is far greater; there may be a total of 74 million cases each year in the United States. Outbreaks have been reported in nursing homes and on military bases and school campuses, but Norwalk-like viruses on cruise ships have made national headlines in the past few years. Attack rates have been as high as 41 percent, reflecting the propensity of infection with Norwalk-like viruses to cause emesis and voluminous stools, and the low inoculum (fewer than 100 viral particles) required to produce infection. The extent of spread in such closed environments may involve nearly 100 percent of exposed persons, since experimental ingestion of infectious material causes symptoms in only 50 to 80 percent of subjects.

Although consumption of contaminated food or water causes large outbreaks of infection with Norwalk-like virus, the importance of person-to-person transmission has been recognized since the initial identification of this organism in an outbreak that affected one third of family members and 50 percent of school contacts. Well-documented secondary outbreaks indicate person-to-person, rather than foodborne, transmission. For example, in a hyperacute outbreak traced to a food handler in a college dining hall, about 20 percent of all cases occurred after the dining hall was closed and were therefore thought to reflect secondary person-to-person spread. In a large community outbreak in Sweden, secondary cases appeared in one third of the households in which a case occurred. Contagion by Norwalk-like viruses has been documented in other circumstances as well. When British soldiers with acute gastrointestinal illness were airlifted out of a combat zone, two flight medics and one hospital staff member subsequently became ill; fecal samples from both the patients and the medical personnel contained Norwalk-like viruses. In another example, 43 members of a football team contracted acute gastrointestinal illness from a single food source. Eleven members of an opposing team also became ill. In a well-documented outbreak in a high school, eight of 15 students in one class became ill after eating lunch at their school cafeteria, whereas the other classes were unaffected, suggesting that the source was a school employee. It is likely that person-to-person transmission occurs in other settings as well, especially when conditions are overcrowded, such as in nursing homes and on military bases.
Table 3. Relevant Features of Selected Acute Gastrointestinal Infections. *

<table>
<thead>
<tr>
<th>Agent</th>
<th>Quantity of Inoculum to Cause Disease</th>
<th>Usual Mode of Transmission</th>
<th>Incubation Period</th>
<th>Usual Symptoms</th>
<th>Diagnostic Methods</th>
<th>Duration of Symptoms</th>
<th>Duration of Shedding</th>
<th>Probability of Human-to-Human Spread†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella typhi</td>
<td>High (10⁵ CFU)‡</td>
<td>Human contact, prepared food, contaminated water</td>
<td>5–14 days</td>
<td>Fever, abdominal pain, diarrhea</td>
<td>Blood culture, fecal culture</td>
<td>3–4 wk</td>
<td>2–6 wk, rarely lifetime</td>
<td>High</td>
</tr>
<tr>
<td>Salmonella (nontyphoidal)</td>
<td>Low (10⁻¹⁻¹⁰³ CFU)</td>
<td>Poultry, eggs, meat</td>
<td>24 hr (8–24 hr)</td>
<td>Diarrhea, fever</td>
<td>Fecal culture</td>
<td>2–4 days</td>
<td>5 wk, rarely lifetime</td>
<td>Very low</td>
</tr>
<tr>
<td>Shigella</td>
<td>Low (≤10² CFU)</td>
<td>Human contact, prepared food, contaminated water</td>
<td>3 days (1–7 days)</td>
<td>Diarrhea, fever</td>
<td>Fecal culture</td>
<td>3 days (2–6)</td>
<td>Days to weeks</td>
<td>Very high</td>
</tr>
<tr>
<td>Campylobacter</td>
<td>Low</td>
<td>Poultry, milk, tap water</td>
<td>3 days (1–7 days)</td>
<td>Diarrhea, fever</td>
<td>Fecal culture</td>
<td>3 days (1–7)</td>
<td>50% negative after 3 wk</td>
<td>Very low</td>
</tr>
<tr>
<td>Calicivirus</td>
<td>Low</td>
<td>Human contact (feces, vomitus), prepared food</td>
<td>1 day (1–2 days)</td>
<td>Diarrhea, vomiting, fever</td>
<td>RT-PCR</td>
<td>2 days (1–3)</td>
<td>3 days (1 day to weeks)</td>
<td>Very high</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>Very low</td>
<td>Human contact</td>
<td>2 days</td>
<td>Fever, vomiting, diarrhea (in infants)</td>
<td>EIA, latex agglutination</td>
<td>4 days (3–9)</td>
<td>4 days (2–7 days)</td>
<td>Very high</td>
</tr>
<tr>
<td>Astrovirus</td>
<td>Unknown</td>
<td>Human contact</td>
<td>1–2 days</td>
<td>Diarrhea</td>
<td>EIA (not commercially available)</td>
<td>2–5 days (1–14)</td>
<td>4 days (1 day to weeks)</td>
<td>High</td>
</tr>
<tr>
<td>Adenovirus types 40 and 41</td>
<td>Unknown</td>
<td>Human contact (feces, possibly vomitus)</td>
<td>2–3 days</td>
<td>Diarrhea, vomiting, fever</td>
<td>EIA (not commercially available)</td>
<td>2–4 days (1–7)</td>
<td>5 days (3–11 days)</td>
<td>Low</td>
</tr>
<tr>
<td>Giardia</td>
<td>Low (≤10² organisms)</td>
<td>Tap water, human contact</td>
<td>9 days (1–2 wk)</td>
<td>Abdominal discomfort, diarrhea</td>
<td>Microscopical examination of feces</td>
<td>1–8 wk</td>
<td>3 wk–6 mo</td>
<td>High</td>
</tr>
<tr>
<td>Cryptosporidium</td>
<td>Very low (1–2 cysts)</td>
<td>Tap water, human contact</td>
<td>7 days (1–14 days)</td>
<td>Diarrhea, abdominal pain, headache, fever</td>
<td>Microscopical examination of feces</td>
<td>10–12 days (3–60)</td>
<td>7 days</td>
<td>Very low</td>
</tr>
</tbody>
</table>

* This table is subject to the limitations of the medical literature (for some organisms, clinical studies are more detailed, whereas for other organisms the documentation may not exist, although the clinical syndromes may be very similar). In the entries in the columns “Incubation Period,” “Duration of Symptoms,” and “Duration of Shedding,” the numbers in parentheses indicate the range. “Shedding” is the time during which the infectious agent can be recovered from feces after the end of illness. CFU denotes colony-forming units, RT-PCR reverse transcriptase–polymerase-chain-reaction assay, and EIA enzyme immunoassay.
† This column reflects the authors’ assessment of the likelihood of human-to-human spread, based on all the available sources of information as presented in the text.
‡ Experimental studies show a high inoculum, but some clinical observations suggest a low inoculum.
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The team (17 percent) later had acute gastrointestinal illness due to a Norwalk-like virus with an identical genogroup.\textsuperscript{70}

Whereas bacteria causing diarrheal disease are presumably shed exclusively in feces, caliciviruses are detected in vomitus and feces,\textsuperscript{67} and contact with either source may result in infection. Airborne transmission may have caused an outbreak in a geriatric facility in which 9 of 14 employees who contracted acute gastrointestinal illness had no direct contact with the feces of residents.\textsuperscript{71} Similar instances have been cited in other locales, such as cruise ships,\textsuperscript{72} hospitals,\textsuperscript{73} and restaurants,\textsuperscript{74} which suggests that a small inoculum can spread disease by aerosol. Caliciviruses persist in an infectious form in the environment\textsuperscript{75} and are resistant to deactivation by ordinary cleansing agents,\textsuperscript{76} although they are inactivated by exposure to household bleach diluted 1:10.\textsuperscript{77} This explains why, once they are in the environment, for example in a day-care setting or a cruise ship, they are so difficult to eradicate.

**ROTAVIRUSES**

Rotaviruses are a prominent cause of severe diarrheal disease in children under the age of two years. Infection is highly contagious, indicating that a very small inoculum is infectious, since the feces of infected children usually contain no more than 100 CFU per gram. When a rotavirus is introduced into a family, about 50 percent of exposed children and 15 to 30 percent of exposed adults become infected, although some proportion of infected children and most infected adults remain asymptomatic.\textsuperscript{28,78-80} Most adults who are infected become so within the family, whereas most infections in very young children are acquired outside the family — for example, in day-care settings.\textsuperscript{28,81} Like caliciviruses, rotaviruses survive well on environmental surfaces\textsuperscript{82} and are difficult to inactivate,\textsuperscript{83} although diluted household bleach seems to be effective.\textsuperscript{84} The congruence of the small size of the inoculum required for infection,\textsuperscript{85,86} the survival of the pathogen in the environment, and its resistance to most common cleansing agents renders this virus very difficult to control in closed populations; the same is true of the Norwalk-like viruses.

**ADENOVIRUS TYPES 40 AND 41**

Enteric adenoviruses, types 40 and 41, which have been identified only recently by application of novel techniques, are found in the feces of about 3 percent of all young children with acute gastrointestinal illness.\textsuperscript{55,87,88} These viruses are readily transmitted from child to child, with disease developing in about half of infected children; most infected adults remain asymptomatic.\textsuperscript{55,89-91} In a prospective, five-year investigation,\textsuperscript{91} adenovirus type 40 or 41 was found in all 10 outbreaks in which other organisms had not been identified; 38 percent of all fecal samples studied were positive. Nevertheless, one family study suggested that this organism is much less contagious than rotavirus.\textsuperscript{53} In one prolonged outbreak of acute gastrointestinal illness in...
persons hospitalized for long periods, rotavirus and adenovirus type 40 or 41 were isolated in nearly equal proportions.\textsuperscript{92}

**ASTROVIRUS**

Astroviruses, which are perhaps less well studied than the viruses already described, cause outbreaks of acute gastrointestinal illness — generally, but not always,\textsuperscript{93} by person-to-person spread. Day-care\textsuperscript{94} and kindergarten\textsuperscript{57} attendees, military recruits,\textsuperscript{95} and mothers and children in maternal-care facilities\textsuperscript{96} have been implicated, and pediatric\textsuperscript{97,98} and geriatric\textsuperscript{92,99,100} hospital wards have been involved. During outbreaks in day-care centers, 50 to 90 percent of children and up to 25 percent of adults may have disease\textsuperscript{57,94,96}; secondary cases occur in the families of one third of affected children.\textsuperscript{57} This apparently high rate of contagion belies results showing disease in only a very small proportion of human volunteers after experimental ingestion of astrovirus\textsuperscript{101}; the lower rate in the study is perhaps attributable to differences between naturally acquired strains and those used experimentally.

**CRYPTOSPORIDIUM**

Because it can be difficult to eradicate cryptosporidium from drinking water, large outbreaks of infection have occurred.\textsuperscript{106} Nevertheless, person-to-person spread of cryptosporidium\textsuperscript{107} is well documented in homes, schools, and day-care centers. Cryptosporidium may infect 40 percent of household members who have contact with young children with diarrhea, but fewer than 10 percent of household members whose contact is with asymptomatic carriers become infected\textsuperscript{107} — again illustrating the importance of diarrhea in contagion. When adults are infected, the risk for secondary infection in families is less than 5 percent\textsuperscript{108}; in part, this low rate of risk is consistent with the better hygiene of adults, as compared with children, and, in part, it may be due to other, uncertain causes. Food handlers may also spread this organism.\textsuperscript{109}

**GIARDIA**

Outbreaks of infection with giardia in child-care settings are associated with overall attack rates (including clinical and subclinical cases) of 17 to 47 percent among attendees and 10 to 35 percent among adult workers.\textsuperscript{110} When a young child becomes infected, there is a 5 to 25 percent chance that one or more family members will contract the disease.\textsuperscript{28,110} Severe giardiasis occurs most commonly in young children and women of childbearing age,\textsuperscript{111} probably reflecting host susceptibility together with the effect of the size of the inoculum. Giardia also spreads among participants in swimming classes\textsuperscript{112} and among homosexual men.\textsuperscript{113}

**E. HISTOLYTICA**

Outbreaks of *E. histolytica* infection in schools are generally traced to contaminated water sources. Person-to-person spread has, however, been documented in homes, schools, and day-care centers, as well as among homosexual men.\textsuperscript{30,114,115} Nevertheless, somewhat surprisingly, documented spread within families is unusual.\textsuperscript{116,117}

**PREVENTION**

In nearly all instances, transmission of acute gastrointestinal illness is due to organisms that are present transiently on the hands.\textsuperscript{118} The distinction between transient and resident flora is important in understanding apparent discrepancies relating to transmission of acute gastrointestinal illness. Washing the hands for 30 seconds with soap or detergent and water may not substantially reduce the total number of bacteria that are present on relatively clean hands\textsuperscript{119}; in contrast, handwashing reduces by about 95 percent the numbers of bacteria or viruses that are applied to the hands experimentally\textsuperscript{120,121} or that are acquired exogenously under natural conditions\textsuperscript{122}; and handwashing clearly reduces the spread of acute gastrointestinal illness in day-care and family settings.\textsuperscript{123-125} The explanation is that exogenously acquired organisms or transient flora (the ones that are likely to transmit infection) are removable by washing, whereas resident flora (the ones that are normally present) are not.

Whereas the antibacterial substances in household soaps do not prevent acute gastrointestinal illness,\textsuperscript{126} additional field studies with alcohol-based
gels may be warranted in day-care centers and other sites where the risk of person-to-person transmission is particularly high. As noted above, washing environmental surfaces with solutions containing diluted household bleach (1:10) greatly reduces the counts of bacteria and viruses that are implicated in acute gastrointestinal illness, but this type of application is not always practicable.

SUMMARY AND CONCLUSIONS

Acute gastrointestinal illness is exceedingly common; viruses, bacteria, and protozoa are the principal recognized causes. Some causative organisms, such as calicivirus, rotavirus, astrovirus, adenovirus types 40 and 41, S. typhi, and shigellosis, are indigenous to humans; person-to-person spread follows direct contact or human contamination of food or water. In contrast, nontyphoidal salmonella, campylobacter, and pathogenic E. coli are prevalent in meat, poultry, and dairy foods; human-to-human spread is documented infrequently relative to the total number of cases of infection with these bacterial agents. This lower rate of documentation may reflect the difficulty, in an individual case, of determining whether some common food source is responsible or in distinguishing an environmental source from a human source.

As a general matter, the failure to identify a common source for most sporadic, presumably viral, acute gastrointestinal illnesses does not exclude the possible link to an unrecognized foodborne outbreak. The essential point remains, however, that — even though the visibility of an outbreak tends to focus attention on foodborne infection — the great majority of cases are sporadic and spread from person to person. Although free-living protozoa, such as cryptosporidia or giardia, are widespread in nature, contagion is also well documented.

The likelihood of contagion depends on the age and self-reliance of an infected person, the nature of the social interaction within the potentially involved group, the intensity of the symptoms, the concentration of organisms in the potentially infective material, the likelihood that the organism will survive direct transmission or survive in the environment, and other, less well understood factors.

Within families, young children are the usual source for contagion because of their exposure to other children, their imperfect personal hygiene, and their dependence on adults. Severely affected persons are more contagious because they discharge greater volumes of infective material that contain large numbers of infectious particles. The likelihood of contagion varies with the concentration of organisms in excreta, the capacity of the organisms to survive and replicate in food or persist in the environment, and the number required to infect. Spread of acute gastrointestinal illness is common and problematic in all closed environments such as day-care centers, schools, and cruise ships.

Person-to-person transmission is best prevented by the practice of excellent personal hygiene both by infected persons and by those exposed to them. Fecal–oral transmission is the usual route of spread of acute gastrointestinal illness, but caliciviruses and probably adenoviruses are present in vomitus, so kissing or sharing utensils should also be avoided. Dilution by handwashing reduces the inoculum of causative organisms, greatly diminishing the risk of contagion. There is no apparent benefit from the antibacterial agents in soaps, although the regular use of alcohol-based gels will probably reduce transmission. The use of diluted household bleach on environmental surfaces may be necessary to interrupt transmission of viral or protozoal agents.

Dr. Daniel Musher reports having received Merit Review Funding from the Department of Veterans Affairs, grant support from Romark Laboratories, and consulting fees from Aventis.

We are indebted to Marsha Sullivan and the staff of the Medical Library at the Michael E. DeBakey Veterans Affairs Medical Center, Houston, for their help.

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