

A population-based estimate of the burden of diarrhoeal illness in the United States: FoodNet, 1996–7

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SUMMARY

This study was performed to better understand and more precisely quantify the amount and burden of illness caused by acute diarrhoea in the United States today. A telephone-based population survey was conducted between 1 July, 1996, and 31 June, 1997, in sites of the Foodborne Diseases Active Surveillance Network (FoodNet). The overall prevalence of acute diarrhoea in the 4 weeks before interview was 11%, giving a rate of 1·4 episodes of diarrhoea per person per year. The rate of diarrhoeal illness defined as a diarrhoeal episode lasting longer than 1 day or which resulted in significant impairment of daily activities was 0·7 per person per year. It can be concluded that acute diarrhoea is common and represents a significant burden of illness in the United States. Our data on self-reported diarrhoea, when generalized to the entire nation, suggests 375 million episodes of acute diarrhoea each year in the United States. Many of these episodes are mild. However, our data also indicate that there are approximately 200 million episodes of diarrhoeal illness each year in the United States.

INTRODUCTION

Although acute diarrhoea is known to be common in the United States and worldwide, precise estimates of the incidence of diarrhoea in the general population are unavailable. Previous estimates of the incidence and burden of acute diarrhoea in the United States are based on limited information collected decades ago [1,

2]. Such reports have stated that acute diarrhoea is a leading cause of morbidity [3], resulting in an estimated 99 million episodes per year; 8–12 million physician consultations; 462 000–728 000 hospitalizations; 25–43 million restricted-activity days; and 3100 deaths in the United States per year [3]. Newer estimates published by the Centers for Disease Control and Prevention (CDC) suggest that 211 million episodes of acute gastroenteritis occur each year in the United States, resulting in over 900 000 hospitalizations and over 6000 deaths [4]. The data in this paper, derived from the Foodborne Diseases Active Surveillance Network (FoodNet) population

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survey, form part of the basis for the more recent estimates.

FoodNet is the primary foodborne diseases component of the Emerging Infections Program of the CDC. FoodNet is a collaborative programme among CDC, state health departments in FoodNet sites, the US Department of Agriculture (USDA), and the US Food and Drug Administration (FDA) [5–7]. FoodNet sites include selected counties in California (Alameda, San Francisco), Connecticut (Hartford, New Haven), Georgia (Clayton, Cobb, DeKalb, Douglas, Fulton, Gwinnett, Rockdale), and all counties in Minnesota and Oregon.

METHODS

A telephone-based population survey was conducted between 1 July 1996, and 31 June 1997, in sites of the Foodborne Diseases Active Surveillance Network (FoodNet). The 1996 post-census estimate of the population within these FoodNet sites was 14·3 million, or 5% of the US population. Each month, approx. 150 persons in each site were interviewed.

Interviews were conducted using methods similar to those used in the Behavioral Risk Factor Surveillance System (BRFSS) [8–10]. Following screening to remove business and non-working telephone numbers, respondents were contacted using a random digit dialing, single-stage, Genesys-ID sampling method. All interviews were conducted in English.

Respondents were asked about demographic characteristics. Place of residence was categorized as urban if the respondent reported living in a city or town of $\geq 50\,000$ residents. Respondents were also asked about the occurrence of diarrhoea in the 4 weeks before interview. Persons who reported having diarrhoea in this 4-week time period were asked about the occurrence of other symptoms, the duration of the diarrhoea, the maximum number of bowel movements during a 24 h period, and their ability to perform daily activities, such as attending school or work. These respondents were also asked what they thought caused the diarrhoea, if they took antibiotics or anti-diarrhoeal medications for their illness, and whether they called or visited one or more health-care providers for their illness. Persons with diarrhoea were also asked for the most important reasons why they had chosen either to visit or not to visit a health-care provider for their illness. Persons with diarrhoea who visited a health-care provider were asked how soon after their illness onset they visited this provider,

if their health-care provider had requested a stool sample from them, and if they had provided a stool sample for diagnostic purposes. Persons with diarrhoea who visited a health-care provider were also asked whether they were hospitalized because of their illness.

‘Diarrhoea’ was defined as three or more loose stools or bowel movements in any 24 h period. ‘Diarrhoeal illness’ was defined as diarrhoea lasting longer than 1 day or which resulted in significant impairment of daily activities.

Persons with a chronic illness in which diarrhoea was a major symptom (e.g. colitis, irritable bowel syndrome), or who had had surgery to remove part of their stomach or intestine, were excluded from the analysis. Persons who reported having diarrhoea but then reported having less than three loose stools or bowel movements in a 24 h period were considered not to have had diarrhoea. Persons with ongoing diarrhoea were not included in the analysis of duration of the diarrhoea. Individuals who responded ‘don’t know’, ‘not sure’, or refused to answer a question were not included in the analysis of that question.

The response rate for this survey was calculated using the upper bound response rate formula provided by the Council of American Survey Research Organizations (CASRO). The upper bound calculation includes only refusals, terminations, and completed interviews. Data were analysed using Statistical Analytical Software (SAS, version 6.12) and Software for Survey Data Analysis (SUDAAN, version 7.5) [11]. Data describing diarrhoeal illness were analysed using weighted proportions to compensate for unequal probabilities of selection and to allow for population estimates. Similar to BRFSS methods, unequal probabilities of selection were accounted for by weighting the data using the number of eligible respondents per household and the number of telephone lines in each household. Using 1996 projected census numbers, age and sex adjustments were made so that the survey population was more demographically representative of the FoodNet catchment area. To test the null hypothesis that the prevalence-odds of diarrhoeal illness did not vary with age, education or place of residence, a Wald χ^2 test was performed at a 0·05 significance level. To test the null hypothesis that the differences among prevalences for diarrhoeal illness and calling or visiting a ‘medical person’ for their illness for specified levels of a variable was zero, a *t*-test was performed at a 0·05 significance level. Based on the results from the

Table 1. Demographic characteristics of participants, by site, FoodNet Population Survey, 1 July, 1996–31 June, 1997

	California (n = 1648)		Connecticut (n = 1783)		Georgia (n = 1842)		Minnesota (n = 1748)		Oregon (n = 1603)		Total (n = 8624)	
	n	%	n	%	n	%	n	%	n	%	n	%
Sex												
Male	753	46	769	43	826	45	783	45	749	47	3880	45
Female	895	54	1014	57	1016	55	965	55	854	53	4744	55
Age – in years												
< 5	81	5	80	5	90	5	93	5	81	5	425	5
5–14	108	7	150	8	149	8	169	10	165	10	741	9
15–24	206	13	183	10	178	10	185	11	161	10	913	11
25–44	696	42	608	34	742	40	571	33	512	32	3129	36
45–64	360	22	459	26	474	26	426	24	403	25	2122	25
≥ 65	174	11	272	15	193	11	284	16	266	17	1189	14
Unknown	23	1	31	2	16	1	20	1	15	1	105	1
Race												
White	950	58	1436	81	1191	65	1596	91	1414	88	6587	76
Black	193	12	139	8	488	27	38	2	20	1	878	10
Hispanic	206	13	120	7	66	4	38	2	73	5	503	6
Asian	207	13	26	2	24	1	25	1	41	3	323	4
American Indian	9	1	6	0.3	8	0.4	9	1	19	1	51	1
Other race	53	3	24	1	19	1	15	1	19	1	130	2
Unknown	30	2	32	2	46	3	27	2	17	1	152	2
Education												
Less than high school	136	8	200	11	182	10	222	13	203	13	943	11
High school graduate	736	45	969	54	890	48	963	55	943	59	4501	52
College graduate	765	46	601	34	760	41	554	32	447	28	3127	36
Unknown	11	1	13	1	10	1	9	1	10	1	53	1
Income												
\$ ≤ 15000	211	13	193	11	189	10	243	14	219	14	1055	12
\$ > 15000 but ≤ 30000	263	16	275	15	323	18	342	20	401	25	1604	19
\$ > 30000 but ≤ 60000	466	28	529	30	588	32	563	32	517	32	2663	31
\$ > 60000 but ≤ 100000	289	18	323	18	314	17	222	13	174	11	1322	15
\$ > 100000	158	10	124	7	171	9	100	6	62	4	615	7
Unknown	261	16	339	19	257	14	278	16	230	14	1365	16
Residence												
Urban (≥ 50000 population)	1561	95	1327	74	1643	89	1121	64	1021	64	6673	77
Nonurban (< 50000 population)	72	4	518	25	181	43	612	35	563	35	1872	22
Unknown	15	1	18	1	18	1	15	1	13	1	79	1
Insurance												
With medical insurance	1402	85	1563	88	1558	85	1560	89	1387	87	7470	87
Without medical insurance	158	10	109	6	151	8	99	6	126	8	643	8
Unknown	88	5	111	6	133	7	89	5	90	6	511	6

FoodNet sites and the 1996 post-census estimate of the population, extrapolations were calculated for diarrhoea and diarrhoeal disease for the entire United States.

RESULTS

Overall, 9003 completed interviews were conducted, resulting in an upper bound CASRO response rate of 71%. After excluding 379 respondents who reported

having had a chronic illness in which diarrhoea was a major symptom or who had had surgery to remove part of their stomach or intestine, 8624 respondents were included for analysis. The number of respondents enrolled at each site ranged from 1603 to 1842 (Table 1).

Diarrhoea and diarrhoeal illness

The overall prevalence of self-reported acute di-

Table 2. *Weighted prevalence of diarrhoeal illness, calling and visiting a medical person, stool sampling and hospitalization, FoodNet Population Survey, 1 July, 1996–31 June, 1997*

	% of participants (<i>n</i> = 8624) with diarrhoeal illness		% of persons with diarrhoeal illness (<i>n</i> = 492), who called a medical person		% of persons with diarrhoeal illness (<i>n</i> = 492), who visited a medical person		% of persons who visited a medical person (<i>n</i> = 61), who had a stool sample requested		% of persons who had a stool sample requested (<i>n</i> = 19), who submitted a stool sample		% of persons who visited a medical person (<i>n</i> = 61), who were hospitalized	
	%	±95% CI†	%	±95% CI	%	±95% CI	%	±95% CI	%	±95% CI	%	±95% CI
Sex												
Male*	5	0.9	19	7.0	12	5.7	24	17.8	83	26.3	0.8	1.6
Female	6	0.8	20	5.5	11	4.2	20	13.1	96	7.7	14‡	10.9
Age (years)												
< 5*	10	3.1	44	17.0	23	15.4	7	13.3	100	0	0	0
5–14	5‡	1.8	27	15.2	18	13.7	7	13.4	100	0	0	0
15–24	6‡	1.8	15‡	12.7	8	7.0	37	41.7	88	26.7	23	39.4
25–44	7	1.1	14‡	5.5	8	3.9	21	13.2	95	11.6	0	0
45–64	5‡	1.1	12‡	6.3	8	5.6	46‡	33.7	70	46.9	44‡	33.0
≥ 65	3‡	1.1	19‡	12.5	15	11.6	54‡	44.7	100	0	8	15.2
Race												
White*	6	0.7	18	4.5	11	3.5	22	12.4	88	18.3	7	7.2
Black	5	1.8	22	14.4	15	12.0	13	20.9	70	57.9	22	28.4
Hispanic	7	2.7	33	21.6	10	11.4	57	59.2	100	0	0	0
Asian	4	3.2	37‡	48.7	48	43.9	0‡	0	—	—	0‡	0
American Indian	5	7.7	0	0	0‡	0	—	—	—	—	—	—
Other race	9	6.5	15	27.3	0‡	0	—	—	—	—	—	—
Education												
Less than high school*	5	1.5	20	13.2	16	13.0	30	34.8	100	0	12	18.3
High school graduate	6	0.8	20	6.4	12	5.2	14	11.5	96	8.5	9	9.6
College graduate	7‡	1.1	19	6.5	9	4.1	31	21.1	78	31.7	2	3.4
Income												
\$ ≤ 15000*	7	1.8	31	13.8	14	8.7	30	29.7	91	19.9	22	28.2
\$ > 15000 but ≤ 30000	6	1.5	16	8.8	14	9.3	7	9.3	80	40.9	4	8.1
\$ > 30000 but ≤ 60000	7	1.2	17	6.9	10	5.1	20	19.1	100	0	6	9.6
\$ > 60000 but ≤ 100000	6	1.5	18	9.3	6	5.1	28	36.2	100	0	0	0
\$ > 100000	8	2.7	18	14.8	7	7.3	7	14.6	100	0	5	9.7

Residence														
Urban (≥ 50 000 population)*	6	0·7	23	5·1	14	4·3	19	10·3	88	16·1	6	4·7		
Nonurban (< 50 000 population)	5‡	1·1	8‡	7·4	1‡	2·3	100‡	0	100	0	82‡	40·6		
Insurance														
With medical insurance*	6	0·7	21	4·8	12	3·8	22	11·3	89	15·3	6	5·8		
Without medical insurance	8	2·5	4‡	4·0	5	7·3	0‡	0	—	—	9	20·9		
Total	6	0·6	20	4·4	12	3·5	21	10·8	89	14·3	8	6·1		

* Reference group for statistical testing.

† ± Half width of the 95% confidence interval.

‡ Significantly different from the reference group ($P < 0·05$).

arrhoea in the 4 weeks before interview was 11% (977/8624) (95% confidence interval [CI] 10·2–11·8). This results in a rate of 1·4 episodes of diarrhoea per person per year in the FoodNet sites (977/8624 × 12). The rate of diarrhoeal illness defined as a diarrhoea lasting longer than 1 day or which resulted in significant impairment of daily activities was 0·7 per person per year (492/8624 × 12) (Table 2). The rates of diarrhoeal illness did not vary significantly among the FoodNet sites (χ^2 P -value = 0·099). The remainder of the results refer to those persons who reported diarrhoeal illness.

The prevalence of diarrhoeal illness was highest among children < 5 years of age (10%) and lowest among persons ≥ 65 years of age (3%; $P = 0·001$) (Table 2). The prevalence of diarrhoeal illness increased with increasing level of education ($P = 0·03$). Self-reported diarrhoeal illness was more common in persons living in urban areas (6%) than in persons living in rural areas (5%; $P = 0·04$).

The most common symptoms among persons with diarrhoeal illness were abdominal cramps (65%), fever (32%), vomiting (21%), and bloody diarrhoea (0·9%) (Table 3). The majority of respondents with bloody diarrhoea (66%) described the amount of blood present in their stool as ‘a large amount’, while 34% described the amount of blood in their stool as ‘a small amount’. The median number of stools in a 24 h period was four (range 3–25). The median duration of self-reported acute diarrhoea was 2 days (range 1–30 days); 54% were unable to perform their normal daily activities because of their illness, with a median of 1 day of restricted activity (range 0–30). The most frequently suggested causes of diarrhoea provided by persons with diarrhoeal illness were ‘stomach flu/intestinal flu/caught a virus’ (45%), ‘food poisoning’ (13%), and ‘overeating/fatty foods/spicy foods’ (12%).

Medical actions taken in response to acute diarrhoeal illness

Of persons with diarrhoeal illness, 34% reported taking anti-diarrhoeal medications, 7% antibiotics; 20% reported calling a health-care provider, and 12% reported visiting a health-care provider (Table 3). Among the persons who took antibiotics, 32% took antibiotics without visiting a health-care provider. The most important factors influencing the decision to visit a health-care provider were having a fever (87%), vomiting (79%), ‘how sick they felt’

Table 3. Characteristics of persons with diarrhoeal illness in the 4 weeks before interview, FoodNet Population Survey, 1 July, 1996–31 June, 1997

	Persons with diarrhoeal illness (<i>n</i> = 492) (%)*	Visited a medical person		Submitted stool sample after it was requested		Hospitalized	
		Yes (<i>n</i> = 61) (%)*	No (<i>n</i> = 431) (%)*	Yes (<i>n</i> = 16) (%)*	No (<i>n</i> = 3) (%)*	Yes (<i>n</i> = 8) (%)*	No (<i>n</i> = 53) (%)*
Symptoms							
Abdominal cramps	65	70	64	68	100	64	71
Fever	32	55	29	32	14	43	56
Vomiting	21	31	19	26	32	55	29
Blood in stool	0.9	1	0.8	6	0	0	1
Clinical Characteristics							
Median days of duration (range)	2 (1–30)	3 (1–30)	2 (1–30)	4 (2–30)	14 (10–14)	3 (2–5)	3 (1–30)
Median # stool in 24 hrs (range)	4 (3–25)	5 (3–25)	4 (3–15)	5 (3–25)	5 (3–8)	7 (4–13)	4 (3–25)
Median days of restricted activity	1 (0–30)	3 (0–21)	1 (0–30)	3 (0–10)	4 (1–7)	5 (2–14)	3 (0–21)
Medical actions taken in response to acute diarrhoeal illness							
Took antibiotics	7	40	2	38	68	24	42
Took antidiarrhoeal med	34	29	35	59	18	36	28
Unable to perform daily act	54	61	53	72	32	87	59
Called med person	20	84	11	89	100	100	83
Sought med care	12	100	0	100	100	100	100
Stool sample requested	21	21	—	100	100	76	17
Hospitalized	8	8	—	28	0	100	0

* Weighted prevalence.

(73%), having stomach cramps (64%), blood in stool (51%), and 'how long the diarrhoea lasted' (44%). For persons with diarrhoeal illness, the prevalence of calling a health-care provider was highest among children < 5 years of age and lowest among persons between 45 and 65 years of age (Table 2). Calling and visiting a health-care provider were more common in respondents living in urban areas than in respondents living in rural areas. The prevalence of calling or visiting a health-care provider was higher among respondents with medical insurance than among respondents without medical insurance (Table 2). The most commonly expressed reasons for not visiting a health-care provider were that the illness 'did not last long enough' (38%) and that the illness 'was too mild' (28%).

Of persons who did visit a health-care provider, 70% had abdominal cramps, 55% had fever, 31% had vomiting, and 1% had blood in the stool. Among persons who did not visit a health-care provider, 64% had abdominal cramps, 29% had fever, 19% had vomiting, and 0.8% had blood in the stool (Table 3).

The most common health-care providers whom persons with diarrhoeal illness visited first because of their illness were a private medical office (66%), a clinic (19%), and an emergency room (11%), and the care was most commonly provided by a physician (89%). The median time between onset of illness and seeing a health-care provider was 2 days (range 0–30). Of persons who visited a health-care provider, 14% also had a subsequent visit to another health-care provider for their illness. Of these, 59% visited a private medical office, and care was most commonly provided by a physician (84%).

Of the persons who visited a health-care provider, 21% reported being requested to provide a stool specimen; 89% complied with this request (Table 2). Stool samples were most frequently requested from persons \geq 65 years of age and least frequently from children < 5 years of age. Among persons who visited a health-care provider, those who submitted a stool sample more often reported fever (32% *vs.* 14%) and bloody diarrhoea (6% *vs.* none), but less commonly reported abdominal cramps (68% *vs.* all) and vomiting (26% *vs.* 32%) than those who did not submit a stool specimen (Table 3).

Eight percent of persons who visited a health-care provider were hospitalized. The prevalence of hospitalization was highest for persons aged 45–64 (44%). Persons hospitalized, compared with those not hospitalized, more often reported vomiting (55% *vs.*

29%), but less often reported fever (43% *vs.* 56%) and abdominal cramps (64% *vs.* 71%). The median duration of the diarrhoea for hospitalized persons was 3 days (range 2–5). The median number of restricted-activity days was 5 (range 2–14), compared to a median of 3 (range 0–21) days for those not hospitalized.

DISCUSSION

Acute diarrhoea is common and represents a significant burden of illness in the United States. Our data on self-reported diarrhoea in the 4 weeks before the interview indicate that there are 1.4 episodes per person per year, which, when generalized to the entire nation, suggests 375 million episodes of acute diarrhoea each year in the United States. Many of these episodes are mild. If we look further at diarrhoeal illness (that is, episodes of acute diarrhoea in persons who reported a duration of illness longer than 1 day or significant impairment of daily activities), there are 0.7 diarrhoeal illnesses per person per year, or approx. 200 million episodes each year in the United States. The insignificant variation of diarrhoeal illness rates among the FoodNet sites, supports the validity of the generalization.

To put our findings in historical context and to evaluate whether the incidence of diarrhoea is changing, we reviewed previously published studies from the United States and elsewhere. Several US population-based studies have estimated the prevalence of acute diarrhoea and the burden of illness resulting from acute diarrhoea [1, 2, 12]. In the Tecumseh study (1965–9), the largest of the studies, with 4095 person-years involved, a rate of diarrhoea of 0.63 per person-year was estimated [1]. This rate was adjusted by Garthright et al. to 0.52 episodes of acute diarrhoea per person-year by adjusting for the US age distribution [13]. The Tecumseh study used self-defined diarrhoea occurring in the week preceding a phone call from an investigator. The investigators followed selected households weekly for a year. The study lasted 6 years, though any selected household was followed for at most 1 year. The Cleveland study (January 1948 through May 1957) covered 85 different families with 439 different individuals for a total of 2692 person-years [2]. Families recorded illnesses on a monthly tally sheet and were visited weekly by field workers. A total of 4057 cases of 'infectious gastroenteritis' were counted, which included any self-

reported vomiting, diarrhoea, or abdominal pain; approximately 56% of these involved diarrhoea, based on a detailed examination of 2 years' worth of data. The rate of 'infectious gastroenteritis' was 1.52 per person per year; the rate of diarrhoea alone was an estimated 0.84 per person per year, age-adjusted to 0.56. This study found that perhaps as much as 20% of self-reported gastroenteritis is actually primarily a respiratory illness with accompanying gastrointestinal symptoms (e.g. abdominal pain, vomiting, or diarrhoea). In the most recent study (Washington, DC, 1993), which asked 1197 household members from 462 households if anyone in the household had experienced three or more loose or watery stools in a 24 h period in the 2 weeks preceding the interview, a rate of diarrhoea of 0.8 episodes per person-year was observed [12]. Other studies from developed countries found varying rates of diarrhoea [14–17].

Based on the results from our study and multiple other sources, CDC estimates that 211 million episodes of acute gastroenteritis occur each year in the United States, resulting in over 900 000 hospitalizations and over 6000 deaths [4]. Further studies, including an additional installment of the FoodNet survey of the general population, will help to discern trends in diarrhoeal illness in the United States.

Other findings in this survey have important additional practical significance. We found that 7% of persons with diarrhoeal illness took antibiotics for their illness, and that 32% of them took antibiotics without a prior visit to a health-care provider. Antibiotics are not essential in the treatment of most acute diarrhoeas. Treatment with antibiotics does not reduce the duration or severity of the illness when it is viral in origin, and antibiotic treatment may even prolong asymptomatic carriage of salmonella [18–20]. In addition, antimicrobial therapy might make persons more susceptible to infection with antimicrobial-resistant pathogens [21], and unnecessary antibiotic usage can select for antibiotic resistance.

Our study had several limitations. Several groups were not included: persons refusing to participate, persons who did not have a telephone (e.g. institutionalized persons, poor people), persons who did not speak English, persons who could not respond because of physical or mental impairment, persons having a chronic illness in which diarrhoea was a major symptom, and persons who had had surgery to remove part of their intestine. The other groups are not included in the study and may, if they are different

from the normal US population concerning acute diarrhoea, represent a bias when population estimates are made. Persons were asked about having experienced diarrhoea (three or more loose stools in a 24 h period) in the 4 weeks preceding the interview. We cannot, therefore, accurately count persons during that period who had more than one discrete episode of acute diarrhoea. (An episode of acute diarrhoea occurring after 2–3 days without symptoms is generally considered as a new episode of diarrhoea [22].)

Acute diarrhoeal illness has many causes, most of which remain unknown [4]. Helmick has estimated that a large proportion of these causes are caused by infectious agents [3]. Of these infectious causes, many are transmitted by food or water, suggesting opportunities for prevention, namely, maintenance of safe water supplies (e.g. intact sewage systems, well-maintained chlorination devices); improved farm, processing, and slaughterhouse practices; proper food-handling practices; and proper sewage disposal and sanitation. Understanding which illnesses are transmitted by which foods is difficult, given the complex origins and processing of individual food items. Furthermore, food handling and preparation are difficult to quantify and describe in detail. Ongoing disease surveillance to identify outbreaks at an early stage, remove common sources, and monitor high-risk groups, as well as epidemiologic investigations of outbreaks and of sporadic cases to identify risk factors and control measures, are essential for reducing the burden of diarrhoeal illness and preventing future disease. Increased physician awareness of appropriate diagnostic techniques, perhaps through practice guidelines, and continued improvements in laboratory methods will help identify new agents and allow better detection and monitoring of known ones. Finally, public awareness and education are needed to remind the public of old dangers and alert them to new health risks. Despite advances in sanitation, food safety, and therapy, diarrhoeal illness rates have not declined over the past several decades, and diarrhoeal illness continues to pose a substantial threat to the public's health.

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