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Trends in hospitalizations associated with gastroenteritis among adults in the United States, 1979–1995

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SUMMARY

Gastroenteritis (GE) is among the most common illnesses of humans but the burden of disease, its epidemiology, and the distribution of pathogens in adults have not been fully examined. This information is needed to plan prevention strategies particularly for high-risk groups. This study is a retrospective analysis of data from the National Hospital Discharge Survey for the years 1979 through 1995 which describes the disease burden and epidemiology of hospitalizations associated with GE among adults in the United States. Diarrhoea was listed as a diagnosis on an average of 452000 hospital discharges per year representing 1·5% of all hospitalizations among adults. The annual number of GE hospitalizations has decreased by 20% from approximately 500000 in 1979 to 400000 in 1995. The aetiology of 78% of cases coded as GE was undetermined. Until the aetiology of disease can be better established, specific strategies for prevention cannot be developed.

INTRODUCTION

Diarrhoea is generally regarded as a major health problem for children, particularly those in developing countries, where it kills an estimated 3·5 million children each year; however little attention has been focused on the burden and aetiology of diarrhoeal disease among adults [1]. In the United States, diarrhoeal deaths occur at the extremes of ages, with children being the traditional high risk group. Recently, a report estimated that 1600 patients over age 74 die each year from diarrhoea, exceeding the number reported in children by more than 5 times [2, 3]. While the introduction of oral rehydration therapy has coincided with a decrease in diarrhoeal mortality in children, these programmes have not specifically targeted adults, in whom their utility and potential impact are not known.

Furthermore, major advances in our understanding of the aetiology of childhood diarrhoea over the past 25 years have not been extended to include gastroenteritis (GE) in adults. While we might expect major changes in the incidence of gastroenteritis with the appearance of acquired immunodeficiency syndrome (AIDS); the effect of the advent of managed health care, the newly appreciated hazards of contaminated food and water, and the aging of the population on hospitalization rates for GE and its subsequent burden to the nation's health care system have not been fully assessed. Hospital discharge data

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have been used previously to follow trends in hospitalization rates over time and to develop hypotheses regarding causes of acute GE in children [4, 5]. We applied this same approach to study the epidemiology of GE in adults, a group which has been largely neglected.

This report characterizes the epidemiology and disease burden of diarrhoea among adults over a 17-year period (1979–95), using a national survey of hospital discharge records. We describe the seasonal occurrences and reported aetiologies of diarrhoeal diseases that resulted in hospitalization, and examine temporal trends in the distribution of hospitalizations by age, sex, race and geographic region. Since hospitalization for diarrhoea is generally considered a preventable outcome, this study provides data for the development of hypotheses about disease aetiology, risk groups, and modes of transmission that could help focus future research and articulate potential strategies for prevention.

METHODS

Hospitalization data for the period 1979 through 1995 were obtained from the National Hospital Discharge Survey (NHDS), which is conducted by the National Center for Health Statistics (NHCS), Centers for Disease Control and Prevention [6]. The NHDS consists of a nationally representative probability sample of patient discharge records obtained from short-stay, general and children's hospitals in the United States but does not include hospitalizations at federal facilities, i.e. Indian Health Service, Veterans Administration, military, and Public Health Service hospitals. National estimates of the number of hospitalizations were obtained by weighting the sample data according to the NCHS criteria [6]. Weighted estimates of less than 5000 are considered to be unreliable.

The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes were used to extract hospitalizations of adults 20 years of age and older with diarrhoea or gastroenteritis listed as one of the first three diagnoses on the NHDS record. The ICD-9-CM codes included those for diarrhoea of determined aetiology [bacterial (001–003.1, 003.3–005, 008.0–008.5), parasitic (006–006.2, 006.8–007), and viral (008.6–008.8)], and diarrhoeas of undetermined aetiology, including those presumed to be infectious (009.0–009.3) and non-infectious (558.9) [7]. Non-infectious diarrhoeal illnesses with specified diagnoses such as regional enteritis (555.0–555.9), ulcerative colitis (556.0–556.9) and colitis due to radiation (558.1) or toxins (558.2) were not included. Records were selected on the basis of the first three listed diagnoses because earlier studies have determined this to be a reasonable compromise between admissions in which GE was likely to be the primary cause (i.e. the first listed diagnosis) and those in which it was an incidental finding or nosocomial complication (i.e. listed as diagnosis number four or greater) [2]. We assessed this potential for bias by examining a cumulative distribution of GE codes in any of the seven positions available on the discharge records.

Gastroenteritis-associated population-based annual hospitalization rates were examined by age-group (20–49, 50–64, 65–74, and > 74 years of age), sex, race, method of payment and standard census region (Northeast, Midwest, South and West) using national census data for the US resident population [8]. An age-adjustment hospitalization rate that controls for the changing age distribution of the population was calculated by the direct method using the US 1990 population as the standard. Rates are expressed as the estimated number of hospitalizations per 1000 US residents. 1994 intercensal estimates were used for 1995 since estimates for 1995 were not available at the time of analysis. We compared hospitalization rates by demographic characteristic, using a two-tailed t-test ($\alpha = 0{\cdot}05$) (NCHS internal publication) for the last 3 years of the study period, 1993 through 1995. A 1988 design change in NHDS precluded comparisons for the entire study period [9]. The census denominator was assumed to be error free [6]. Standard errors were calculated with SUDAAN software which takes into account the complex sample design [10]. An overall risk of a GE-associated hospitalization for adults age 20 years was estimated by using the density method [11], assuming a life expectancy of 77 years once age 20 was attained [12]. Hospitalizations by month were examined for three different time periods, 1979–83, 1984–8 and 1989–95, corresponding to three distinct periods when GE-associated hospitalizations were high, declining and low respectively. Seasonal patterns were also examined for these three time periods. Hospitalizations were also examined by age group, coded aetiology and length of stay. Admission month was used with discharge year, as discharge month was not available which may have resulted in a small number of records with true admission in the last

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Table 1. *Hospital discharges for gastroenteritis by diagnostic group among adults ⩾ 20 years; 1979–95*

Diagnostic group*	ICD-9 CM Code	Sample	Weighted†		
			Total	Annual	Total (%)
Aetiology unknown					
Presumed infectious origin	009.0–009.3	1372	241798	14223	3·1
Presumed non-infectious	555.9	31718	5740543	337679	74·7
Aetiology known					
Viruses	0008.6, 008.8	5864	1047563	61621	13·6
Bacteria	001–0005.9, 008.–008.5	4395	666339	39196	8·7
Cholera	001.–001.9	8	1275	75	< 0·1
Typhoid and salmonella septicaemia‡	002.0, 003.1–003.9	271	44686	2628	0·6
Paratyphoid	002.1–002.9	14	2761	162	< 0·1
Salmonella gastroenteritis	003.0	588	92060	5415	1·2
Shigella	004–004.9	228	39323	2313	0·5
Food poisoning	005–005.9	442	79492	4676	1·0
E. coli enteritis	008.0	85	12051	709	0·2
Campylobacter	008.43	103	10965	645	0·1
Protozoa§	006–007.9	524	82461	4850	1·1
Amoebiasis§	006–006.9	68	11774	692	0·2
Other protozoa	007–007.9	459	71047	4179	0·9
Total‖		43377	7683843	451991¶	100

* Records are selected on the basis of GE as one of the first three diagnoses; more than one GE associated diagnosis may be listed on a discharge record.
† Estimates < 5000 are unreliable and those 5000–10000 should be interpreted with caution.
‡ Excludes 003.2, localized salmonella infections.
§ Excludes 006.3–006.6 amoebic abcesses.
‖ Numbers add to ⩾ 100% because some records (1–2%) include more than one code for diarrhoea.
¶ This represents 1·5% of the total 29·4 million annual hospitalizations for all diagnoses.

month of the prior year being classified in the following year.

Hospital-fatality rates were calculated based on patients who died in the hospital (deaths/1000 hospitalizations) as well as hospital death rates (hospital GE deaths/1000 people/year). Length of stay in days had a skewed distribution that was normalized by using log-transformation to compare age-groups [10].

RESULTS

Based on a sample of 43377 observations from 1979 through 1995 representing 7·7 million hospitalizations associated with diarrhoea, we estimate approximately 452000 persons over the age of 20 years, or about 2·7 per 1000 adults in the United States, were hospitalized each year with GE (Table 1). This accounts for 1·5% of the estimated 29·4 million annual hospitalizations of adults for all causes, a proportion that remained stable throughout the study period. Most discharges were coded as non-specific diarrhoea presumed to be non-infectious (558·9) (74·7%). Among discharges in which an aetiology was specified, 13·6% were coded as viral, 8·7% as bacterial and 1·1% as parasitic. Of note, salmonella and shigella organisms commonly selected for in diarrhoeal admissions, together represented fewer than 3% of cases. In general, the distribution of aetiologies did not vary by age group except for parasitic infections which were reported in 1·7% of the youngest group (20- to 49-year-olds) compared with 0·9% of 50- to 64-year olds, 0·4% of 65- to 74-year-olds, and 0·3% of the over 74-year-olds (the sample size was too small to allow statistical comparisons).

From 1979 to 1995, the number of GE discharges declined by 20% from approximately 500000 to 400000 per year (Fig. 1*a*). The annual number of discharges was relatively stable from 1979 to 83, declined in the period from 1984 to 1988, and have remained stable from 1988 to 1995. The age-adjusted discharge rate decreased by 38% from 3·4 to 2·1 hospitalizations per 1000 population in the same time period. However, when each age group was examined separately, the annual number of discharges with diarrhoea increased slightly in the elderly (75 years),

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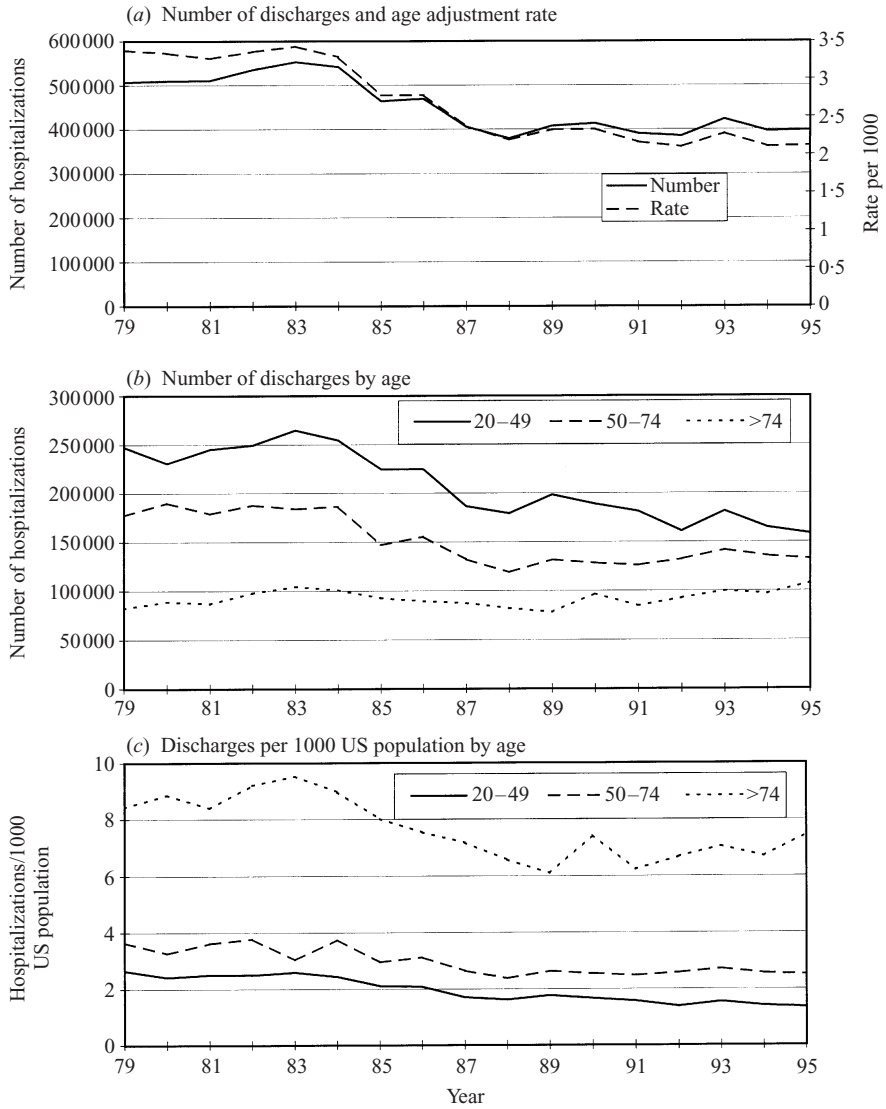

Fig. 1. Trends in annual discharges for GE, 1979–95.

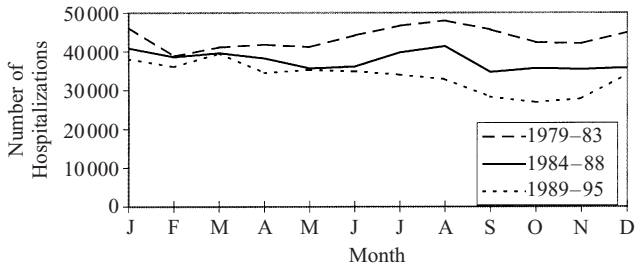

Fig. 2. Average number of GE associated hospitalizations by month and time period.

but decreased in the younger groups; the greatest decline (30%) occurring in the youngest (i.e. 20–49 years) (Fig. 1*b*). To determine whether these trends in discharge numbers could be attributed to changes in the numbers of individuals at risk, we calculated population-based admission rates stratified by age-group using census data, and found that hospitalization rates decreased for all age groups (Fig. 1*c*).

The decrease in hospitalization rates from the beginning to the end of the study period was associated with a change in the seasonality of diarrhoea hospitalizations (Fig. 2). Between 1979 and 1983, the peak number of hospitalizations occurred in summer (August) and the nadir occurred in winter (February), with little variation (19%) from peak to trough (48000 to 39000 admissions per month). This contrasts with the latest period (1989–95), when the peak was in March, the nadir in October and the variation reached 32%. The period in between, corresponding to the time of declining hospitalizations, is one of transition and exhibits a pattern intermediate between the early period and the later period, with only slight seasonal variation.

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Table 2. *Hospitalization rates for gastroenteritis by sex, race, and payor by age-group and for sex by region, 1979–95*

	Age in years			
	20–49 Rate* (%)	50–64 Rate* (%)	65–74 Rate* (%)	⩾ 75 Rate* (%)
Total	1·9 (46)	2·4 (17)	4·2 (16)	7·6 (20)
Sex				
Female	2·5 (64)	3·0 (66)	5·1 (67)	8·6 (73)
Male	1·4 (36)	1·7 (34)	3·2 (33)	5·7 (27)
Race†				
White	1·7 (86)	2·2 (89)	3·8 (91)	6·7 (92)
Black	1·6 (11)	1·8 (7)	3·1 (7)	5·9 (6)
Other	1·6 (3)	2·3 (3)	4·5 (2)	8·1 (2)
Payor‡				
Private Insurance (%)	(69)	(66)	(5)	(3)
None/Medicaid	(23)	(16)	(3)	(2)
Medicare/Unknown	(8)	(18)	(93)	(95)
	Region			
	Northeast	Midwest	South	West
Sex by census region				
Female	2·8 (65)	3·6 (68)	4·1 (68)	2·4 (65)
Male	1·7 (35)	1·9 (32)	2·1 (32)	1·3 (35)

* Rate expressed per 1000 US population.
† Race is not recorded on 13% of records.
‡ Rates were not estimated for pay or status. However, percentages are presented as an indicator of socioeconomic group.

Table 3. *Annual hospitalizations, deaths and summary statistics for diarrhoeal disease in adults: United States, 1979–95*

			Summary statistics			
Age-group (years)	Total deaths*	Total DE discharges†	Deaths/ 1000 discharges	Deaths/ 1000000 population	GE as % of all discharges	Length of stay (days)
20–49	10411	3539142	2·9	5·7	1·6	4·1
50–64	6667	1339974	5·0	11·8	1·4	5·4
65–74	17877	1239933	14·4	60·9	1·5	6·6
⩾ 75	38977	1564794	24·9	188·2	1·6	7·4
Total	73932	7683843	9·6	25·5	1·5	5·4

* Estimates < 5000 are unreliable and those 5000–10000 should be interpreted with caution.
† Hospital discharges for which outcome is known. Outcome was unknown for approx. 1·6% of discharges.

The hospitalization rates for GE varied most by age and sex, and less by region and race (Table 2). Rates increased continuously with age from 1·9/1000 in the youngest group (20–49 years) to 7·6/1000 in the oldest group (75 years) ($P < 0·001$ for each group). In each age-group, females had nearly twice the rate of hospitalization as males and in the oldest age-group, 73% of all GE admissions were for females ($P < 0·001$). Overall, hospitalization rates for whites were higher than for black although not significantly ($P > 0·05$). For all groups, the South had the highest rate, nearly twice that of the West, which had the lowest

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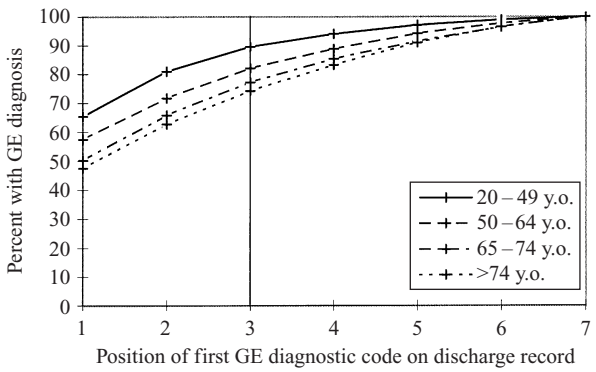

Fig. 3. Cumulative frequency distribution by position on discharge record.

rate ($P < 0{\cdot}001$). Sex differences persisted in all four regions.

An estimated average of 4349 patients with GE died each year during their hospitalization (73923 deaths over a 17-year period), for a fatality rate among persons hospitalized with GE of 9·6 deaths/1000 discharges (Table 3). A majority (53%) of these deaths occurred in the oldest age-group, whose hospital-fatality rate (24·9/1000) was eight times greater than those younger patients 20–49 years of age (2·9/1000). Age-specific, population-based death rates demonstrated an even more dramatic difference; the elderly were 33 times more likely to die during a hospitalization with GE than the young (188 *vs.* 5·7 deaths/1000000/year). These rates appeared to increase over time, but the sample was too small to assume reliability. The mean length of stay increased continuously with age, from 4·1 days in the youngest group to 7·4 days in the oldest. Length of stay also decreased over the entire 17-year period from a mean of 5·8 days during the first 3 years of the study period to 4·8 days by the end of the study period, a decline similar to that seen for all hospitalizations.

The definitions of GE-associated hospitalization used in this study assumes that finding an ICD-9-CM code for GE in one of the first three positions on the discharge record implies this to be a cause for admission. To estimate the potential bias introduced by this assumption, we examined the effect of the position of GE on the discharge record on the estimated burden of GE disease. Of note, patients in the youngest age group compared with those in the oldest age group appeared more likely to have diarrhoea listed in the first position (65 *vs.* 47%) and in the top three positions (90 *vs.* 74%) (Fig. 3). Restricting the case definition to a GE diagnosis in only the first position would have produced a conservative estimate of 313000 annual GE hospitalizations while broadening the definition to include GE in any of the seven positions on the discharge record would have increased the estimate to 546000 hospitalizations per year.

DISCUSSION

This study documents the unexpectedly high burden of diarrhoeal disease in adults. Although the annual risk of an adult being admitted with GE is low, we estimate a lifetime risk for an individual 20 years old to be about one in seven, assuming a lifespan of 77 years [12]. Currently, about 400000 adults are discharged each year with a diarrhoeal illness diagnosis, representing 1·5% of all adult hospitalizations or 2·2 million hospital days. This proportion has remained constant since 1979, as hospitalization rates for all causes have declined at a rate similar to that seen in GE. Major concerns have been raised recently about the increasing risks to the American public from contaminated food and water; however, these concerns are not reflected in a major increase in hospitalizations.

One limitation in deriving useful disease specific rates from these data is that three-quarters of discharge records that list GE as a diagnosis record no specific aetiology. This may reflect the fact that the aetiology of diarrhoeal disease in adults is diverse and is not often sought except in outbreak settings. Examination of other diagnosis listed on the same discharge form did not provide insight into the aetiology of cases given non-specific codes. Irritable colon (564.1) was listed on less than 2% of discharge records included in this study and no other specified, non-infectious cause of diarrhoea occurred on more than 1% of records. It may be that small round structured viruses, which cannot be easily diagnosed in most hospital laboratories but are the agents most often identified in nursing home outbreaks and among the elderly, are important agents in these patients as well [13]. Of particular interest, salmonella, an organism which is easily detected by most hospital labs, is responsible for only 1·2% of all GE admissions, or about 5000 cases per year. A prospective sentinel survey of diarrhoea by Slutzker and colleagues, in which more than 30000 fecal specimens were examined under protocol specifically for bacterial agents, recovered at least one bacterial pathogen in 5·6% of specimens and no identifiable pathogen in 91·6% of stool specimens examined (specimens were

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from inpatients) [14]. This is consistent with our finding of 8·7% of cases listing bacteria as the cause of diarrhoeas. The shift in the seasonal occurrence of diarrhoeal hospitalizations which coincided with the decline in hospitalization rates may reflect a recent change in aetiologic agents as bacterial diarrhoeas are generally more common in the summer and viral diarrhoea peak in the winter. However, significant seasonality may be obscured somewhat by the large baseline rate of diarrhoea caused by a wide variety of aetiologies that are unspecified. This absence of an aetiological diagnosis in so many cases raises several problems for planning prevention strategies. It is impossible to identify the potentially preventable fraction including the portion that are associated with contaminated food and water and disease that is due to non-infectious causes without further investigation.

Our study provides few insights into groups at high risk of disease, exposures, or modes of transmission in specific need of intervention. The elderly are at highest risk of dying during a GE-associated hospitalization. Of the more than 4300 deaths that occur each year among patients hospitalized with GE, more than half are in persons over the age of 74, making the elderly the highest risk group for a fatal outcome even when compared to infants [15]. Females, on the other hand, were found to have a significantly higher rate of admission than males in all age-groups. We examined other diagnoses listed on our GE case records but did not find associated conditions peculiar to females that might have had a confounding effect. Females have been noted to have an increased incidence of diarrhoeal disease in other studies of both inpatients and outpatients [16]. In contrast, male children have a higher incidence of GE than female children. Though blacks had a slightly lower rate of GE hospitalization than whites, race was not a significant risk factor for diarrhoeal admission in our study and the racial differences did not persist throughout the 17-year period. Moreover, race data from the NHDS should be interpreted with caution as it is often omitted on discharge records and may be unreliable [17].

While our mortality estimates are made from a small sample, other investigators, using different data sources, have found death rates among the elderly in the same range as the current study [2, 3]. Gangarosa and colleagues found age to be the most important risk factor for death in patients hospitalized for diarrhoea and reported a hospital-fatality rate in elderly patients similar to reported here [2] Lew and colleagues, using national vital statistics data, found that 51% of deaths in patients hospitalized with diarrhoea were in persons over 74 years of age (1623 deaths per year for the years 1979–87) and that females were at higher risk than males [3]. Direct comparisons with our study data are difficult because of differences in case definition and the reporting method for the cause of death used on death certificates. Whereas death certificate records specify the immediate cause of death, discharge records used in this study do not offer that level of detail.

The decline in hospitalization rates for GE that we observed in adults has also been observed previously in children over the same period of time, implying that similar factors may play a role [4, 5]. However, diarrhoea death among children have declined much more markedly than that observed for adults. Reasons for the decline in hospitalizations are not entirely clear but coincide with the adoption of Diagnosis Related Groups for reimbursement, the increase in persons enrolled in managed-care programmes and the increased use of oral rehydration solutions in outpatient therapy [15]. Of note, data from outpatient surveys have shown constant or increasing incidence rates of diarrhoeal disease over the same time period [16]. No data are available regarding the use of oral rehydration solution in the outpatient treatment of adult diarrhoeal disease.

Our ability to draw conclusions about changes over time is limited because of a change in the NHDS design in 1988. The direction and magnitude of the trend are believed to be real, as those changes occurred over a 4-year period and did not coincide directly with the design change. While this study assumes that listing GE as one of the first three discharge diagnoses implies a relationship to the cause of admission, admitting diagnosis is not coded, so the actual reason for admission is not available. The treating physician is generally responsible for prioritizing the order of diagnoses on a hospital discharge record and this order may be influenced by the level of reimbursement. The order of diagnoses on the discharge record is preserved on the NHDS with two exceptions; myocardial infarction and admission for delivery [18]. Any potential bias introduced by the ordering of diagnoses would likely be toward listing more critical conditions other than gastroenteritis higher on the discharge diagnosis list that would in turn push diarrhoea out of the first three positions. The annual rates reported also assume one hospitalization per individual per year which may not be the case, as some patients with chronic conditions will be admitted more than once

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for diarrhoea. Coding errors are an ever-present problem in using data sets of this type, although the NHDS routinely checks a sample of the data set to estimate coding errors. In recent years, data are increasingly being coded by commercial abstracting services and submitted electronically, making such estimates less meaningful.

It is likely that the downward trend in hospitalization represents a decrease in admissions rather than a decrease in incidence of GE. It is also apparent that the effectiveness of methods introduced in the mid 1980s to decrease hospitalization rates has reached a plateau in the last 7 years for diarrhoeal disease. Any further gains to be made in reducing hospitalization rates will require new interventions, with particular attention to the groups at highest risk, females and the elderly. Current recommendations for intervention in diarrhoeal disease are non-specific, including hand washing, use of oral rehydration solutions, general infection control measures and the protection of food and water sources. Finding the aetiology of the diarrhoea hospitalizations currently labelled 'non-specific' using the best available diagnostic tests is imperative if more specific interventions are to be made and further reductions in hospitalization rates achieved.

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REFERENCES

1. Bern C, Martines J, de Zoysa I, Glass RI. The magnitude of the global problem of diarrhoeal disease: a ten year update. Bull WHO 1992; **70**: 705–14.
2. Gangarosa RE, Glass RI, Lew JF, Boring JR. Hospitalizations involving gastroenteritis in the United States, 1985: the special burden of the disease among the elderly. Am J Epidemiol 1992; **135**: 281–90.
3. Lew JF, Glass RI, Gangarosa RE, Cohen IP, Bern C. Diarrheal deaths in the United States, 1979–1987: a special problem for the elderly. JAMA 1991; **265**: 3280–4.
4. Jin S, Kilgore PK, Holman RC, Clarke MJ, Gangarosa EJ, Glass RI. Trends in hospitalizations for diarrhea in United States children from 1979–1992: estimates of the morbidity associated with rotavirus. Pediatr Infect Dis J 1996; **15**: 397–404.
5. Parashar UD, Holman RC, Clarke MJ, Bresse JS, Glass RI. Hospitalizations associated with rotavirus diarrhea in the United States, 1993 through 1995: surveillance based on the new ICD-9-CM rotavirus-specific diagnostic code. J Infect Dis 1998; **177**: 13–7.
6. National Center for Health Statistics. National Hospital Discharge Survey multi-year public use data tapes 1979–1995. Hyattsville, Md.: National Center for Health Statistics, 1997.
7. Public Health Service and Health Care Finance Administration. International classification of diseases, 9th revision; clinical modification, 6th ed (CD-ROM). Washington, DC: Public Health Service, 1997.
8. Bureau of the Census. Intercensal estimates of the population by age, sex, and race: 1970–1994. Washington, DC: Bureau of the Census, 1997.
9. Haupt BJ, Kozak LJ. Estimates from two survey designs: National Hospital Discharge Survey. Hyattsville, Md: National Center for Health Statistics, 1992; DHHS publication no (PHS) 92–1772. (Vital and health statistics; series 13; no. 111).
10. Shah VB, Barnell BG. SUDAAN user's manual, Release 7.0. Research Triangle Park, NC: Research Triangle Institute, 1996: 6–1–6–39.
11. Kleinbaum DG, Kupper LL, Morgenstern H. Epidemiologic research. New York: Van Norstrand Reinhold Compány, Inc, 1982: 106–11.
12. US Bureau of the Census. Statistical abstracts of the United States, 1995. 115 ed. Washington, DC: US Bureau of the Census, 1995.
13. Kaplan JE, Feldman R, Campbell IP, Lookabaugh C, Gary GW. The frequency of a Norwalk-like pattern of illness in outbreaks of acute gastroenteritis. Am J Public Health 1982; **72**: 1329–32.
14. Slutsker L, Ries AA, Greene KD, et al. *Escherichia coli* 0157:H7 diarrhea in the United States: clinical and epidemiological features. Ann Intern Med 1997; **126**: 505–13.
15. Kilgore PE, Holman C, Clarke MJ, Glass RI. Trends of diarrhea disease-associated mortality in U.S. children, 1968 through 1991. JAMA 1995; **274**: 1143–8.
16. Helmick CG, Griffin PM, Addiss DG, Tauxe RJ, Juranek DD. Infectious diarrheas. In: Everhart JE, ed. Digestive diseases in the United States: epidemiology and impact. Washington, DC: National Institutes of Health, National Institutes of Diabetes and Digestive and Kidney Diseases, 1994. NIH publication no. 94–1447: 85–122.
17. Kozak LJ. Underreporting of race in the National Hospital Discharge Survey. Advance data from vital and health statistics. Hyattsville, Md.: National Center for Health Statistics, 1995; DHHS publication no. (PHS) 95–1250.
18. Graves EJ. National Hospital Discharge Survey: annual summary, 1990. Hyattsville, Md.: National Center for Health Statistics, 1993. DHHS publication no (PHS) 95–1782. (Vital and health statistics; series 13 no. 112).