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Population-based estimate of the burden of acute gastrointestinal illness in Jiangsu province, China, 2010–2011

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SUMMARY

To determine the burden and distribution of acute gastrointestinal illness (AGI) in the population, a cross-sectional, monthly face-to-face survey of 10 959 residents was conducted in Jiangsu province between July 2010 and June 2011. The adjusted monthly prevalence was 4·7% with 0·63 AGI episodes/person per year. The prevalence was the highest in children aged <5 years and lowest in persons aged $\geqslant 65$ years. A bimodal seasonal distribution was observed with peaks in summer and winter. Regional difference of AGI prevalence was substantial [lowest 0·5% in Taicang, highest 15·1% in Xinqu (Wuxi prefecture)]. Healthcare was sought by 38·4% of the ill respondents. The use of antibiotics was reported by 65·2% of the ill respondents and 38·9% took antidiarrhoeals. In the multivariable model, gender, education, season, sentinel site and travel were significant risk factors of being a case of AGI. These results highlight the substantial burden of AGI and the risk factors associated with AGI in Jiangsu province, China.

Key words: Acute gastrointestinal illness, cross-sectional studies, epidemiology.

INTRODUCTION

Acute gastrointestinal illness (AGI), usually presenting as diarrhoea and vomiting, is a common and important public health problem worldwide [1]. It is recognized as one of the leading causes of morbidity and mortality in developing countries, especially for children aged <5 years [2]. While AGI mortality is low in developed countries, AGI morbidity remains important. In the USA about 179 million episodes of AGI occur each year and result in 600 000 hospitalizations and 5000 deaths [3, 4]. Although AGI is usually self-limiting, due to the high annual number of individuals affected, illness imposes a substantial economic burden upon the population and healthcare system [5].

Although AGI is very common in the community, cases of AGI tend to be under-reported by traditional surveillance, which requires cases to present to the healthcare system. To address this, several population-based studies have been conducted in developed countries in order to obtain more accurate estimates of incidence [6–9]. Measuring the actual disease burden within the population is important

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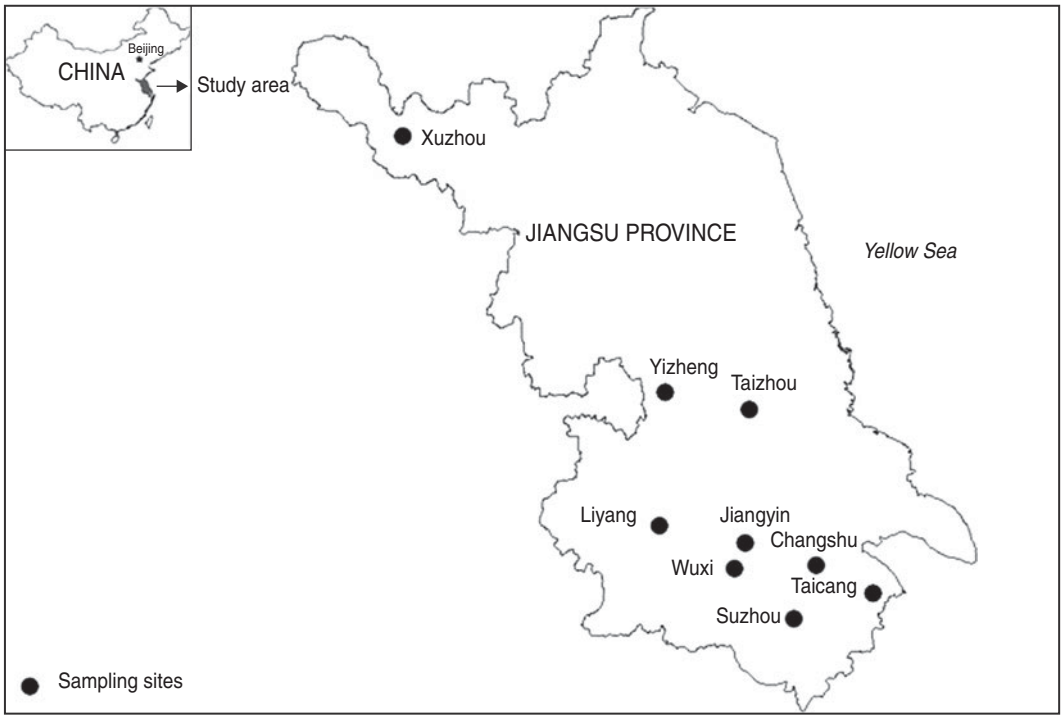

Fig. 1. Map of the sampling sites in Jiangsu province, China.

for understanding of disease dynamics and guiding prevention strategies for gastroenteritis, especially foodborne diseases.

In China, information on AGI comes mainly from hospital-based or laboratory-based surveillance [10, 11]. To adjust hospital-based measurements of the burden of AGI in China, the Chinese Center for Disease Control and Prevention launched a national population-based study on AGI in 2010. The data presented in this paper are from a subsample of participants from Jiangsu province. We conducted the first community survey to estimate the number of cases of AGI in Jiangsu province, China between July 2010 and June 2011. The objectives of the present study were to determine the temporal and demographic distribution of AGI in the population, investigate the burden of self-reported AGI, describe healthcare-seeking behaviour for AGI and identify risk factors associated with AGI.

METHODS

Study design and sample

A cross-sectional, face-to-face survey was administered from July 2010 to June 2011 within nine purposively selected sentinel sites in Jiangsu province (Fig. 1). The sentinel sites were selected based on their suitability, willingness of local authorities and feasibility of completing the studies. The sentinel sites were: (i) Xinqu (Wuxi prefecture) (population 404 573), (ii) Quanshan (Xuzhou prefecture) (population 615 007), (iii) Canglang (Suzhou prefecture) (population 325 696), (iv) Hailing (Taizhou prefecture) (population 374 267), (v) Jiangyin (population 1 420 105), (vi) Changshu (population 1 066 400), (vii) Taicang (population 538 506), (viii) Liyang (population 765 842) and (ix) Yizheng (population 608 092). The sentinel sites represent about 7·9% of the total Jiangsu permanent resident population (77 250 011) in 2009.

Each sentinel site was divided into several blocks in terms of population proportioned distribution. In total, we generated 693 blocks from the nine sentinel sites. Households were randomly selected from each block and the number of households surveyed was proportional to population size. Within each household, one individual with the next birthday was selected to participate in the survey. Up to three attempts were made to contact the selected individual at different times of the day to complete the survey. If the selected individual declined or no one lived at the residence, the neighbouring house (i.e. the nearest residence), was selected as replacement. Proxy respondents were used for all children aged <12 years and for individuals aged 12–18 years when parental

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consent was not given to interview them directly. Written and informed consent was obtained from all respondents before the interview. Surveys were administered in Chinese.

A target sample size of 1110 interviews per region was calculated to detect a prevalence of 7%, with a 5% level of precision and a 1·5% allowable error. This translated into a total of 9990 interviews, with an overall allowable error of 0·5% (Epi Info v. 3.0.2; CDC, USA). To achieve this target, about 93 interviews were completed each month for each sentinel site over a 12-month period.

Data collection

Household interviews were performed by trained healthcare workers using a standard questionnaire. The questionnaire was validated and developed specifically for the purposes of this study. All respondents were asked if they suffered from diarrhoea, or vomiting in the 4 weeks prior to the interview. If the respondent reported diarrhoea or vomiting, they were asked for more details regarding symptoms and timing, what they thought had caused their illness, travel to other city/province, the use of medical consultation and treatment, admission to hospital and whether a stool sample was sent for diagnostic purposes, the social and economic impact of illness, and illness in other members of the household. Additional questions were asked about demographic factors, including the respondent's sex, age, information on household size and occupation.

Case definition

AGI was defined as diarrhoea of $\geqslant 3$ loose stools in a 24-h period or significant vomiting with at least one other symptom (abdominal pain/cramps, fever). All analyses excluded those persons who considered their symptoms to be due to non-infectious causes of diarrhoea or vomiting such as Crohn's disease, irritable bowel syndrome, ulcerative colitis, excess alcohol, pregnancy, menstruation, or medication known to cause vomiting. A 7-day symptom-free interval was defined to distinguish multiple episodes. In case of multiple episodes, only the most recent episode of AGI was used.

Data analysis

Data were entered into EpiData version 3.1 (EpiData Association, Denmark) creating one database for each sentinel site each month. All the data analyses were performed using the software package SPSS, version 16.0 (SPSS Inc., USA).

Response rate was calculated by dividing the number of completed surveys by the number of households visited. The monthly prevalence of AGI was calculated as the number of respondents reporting AGI in the 4 weeks prior to the interview divided by the total number of respondents. The incidence rate of AGI/person per year was calculated using the terminology and formulae outlined by Rothman & Greenland [7, 12, 13].

These estimates were adjusted for known differences between the survey sample and the target population by weighting for age and sex using the fifth national population census data of Jiangsu province as the reference population. The χ^2 test was used for testing the association between demographic factors and the occurrence of AGI. Mean duration of diarrhoea with respect to different age groups was compared by analysis of variance (ANOVA). Values of $P<0{\cdot}05$ were considered statistically significant. Multivariable logistic regression was used to estimate odds ratios (ORs) for each of the geographical, demographic variables. Weighting was not included in the logistic regression since the purpose of the analysis was to identify relative ORs among risk factors. In multivariable analysis, to determine the variables in the model we used the forward elimination method. Explanatory variables tested were gender, age, education, occupation, household size, household type, residence, season, sentinel site and travel history. Variables with $P<0{\cdot}05$ were included in the final model.

RESULTS

Response rate and prevalence of AGI

The overall response rate was 87% with 10959 completed interviews. Of the 10959 persons included in the survey, 490 (4·5%) reported having experienced symptoms of gastroenteritis in the previous 4 weeks. Of these respondents, 45 were declared due to non-infectious causes and included in the non-case category, leaving 445 respondents to be identified as cases. After excluding these respondents, an overall prevalence of AGI in the month before interview, adjusted for age and sex, was 4·7% [95% confidence interval (CI) 4·4–5·1]. This represents an average of 0·63 (95% CI

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Table 1. *Demographic characteristics and weighted monthly prevalence of reporting acute gastrointestinal illness (AGI) in the 4 weeks prior to interview in Jiangsu province, China, July 2010–June 2011*

Variable	Proportion of residents	Proportion of survey respondents	Monthly prevalence of AGI	
			%	(95% CI)
Gender				
Male	50·6	60·4	4·5	(4·0–5·1)
Female	49·4	39·6	5·0	(4·4–5·5)
Age (years)**				
0–4	4·1	1·3	11·6	(8·7–14·6)
5–14	15·5	2·2	6·2	(5·0–7·3)
15–24	14·0	4·5	5·0	(3·9–6·1)
25–44	35·6	32·4	3·8	(3·2–4·4)
45–64	21·9	43·1	4·2	(3·4–5·1)
⩾65	8·9	16·5	3·6	(2·4–4·8)
Education**				
Preschool children	5·3	1·9	10·5	(8·5–12·5)
Illiterate	8·5	5·8	4·9	(2·8–7·0)
Primary	32·9	20·7	4·9	(4·0–5·8)
Secondary	46·5	51·6	4·0	(3·5–4·6)
Tertiary	5·4	12·8	4·0	(3·1–5·0)
University	1·4	7·2	3·8	(2·6–5·0)
Occupation**				
Labourer	n.a.	20·0	3·6	(2·8–4·5)
Services	n.a.	3·1	3·9	(1·9–5·9)
Administrator/director	n.a.	3·0	2·4	(0·5–4·3)
Office staff	n.a.	6·0	4·2	(2·8–5·6)
Professional	n.a.	5·9	5·3	(3·5–7·1)
Farmer	n.a.	27·3	4·2	(3·3–5·1)
Self-employed	n.a.	7·2	3·6	(2·2–5·0)
Retired	n.a.	15·0	3·6	(2·4–4·8)
Unemployed	n.a.	4·3	5·4	(3·3–7·4)
Too young to work (including students)	n.a.	5·3	7·0	(6·1–8·0)
Others	n.a.	2·8	2·9	(1·0–4·8)
Household size (no. of persons)				
1–2	29·4	22·0	3·9	(2·9–4·8)
⩾3	70·6	78·0	4·9	(4·5–5·3)
Household type**				
No residents <18 years	n.a.	50·1	3·8	(3·3–4·4)
At least one resident <18 years	n.a.	49·9	5·3	(4·8–5·8)
Residence				
Urban	42·3	41·0	4·8	(4·2–5·5)
Rural	57·7	59·0	4·7	(4·2–5·2)
Travel*				
Yes	n.a.	3·6	6·8	(4·4–9·2)
No	n.a.	96·4	4·7	(4·3–5·1)

CI, Confidence interval; n.a., not available.
* $P<0·05$, ** $P<0·01$.

0·62–0·64) occurrences of AGI/person per year. A total of 22 people still had symptoms of AGI at the time of interview, yielding a point prevalence of 0·2%.

Distribution

The demographic distribution of residents and survey respondents are shown in Table 1. In general, survey

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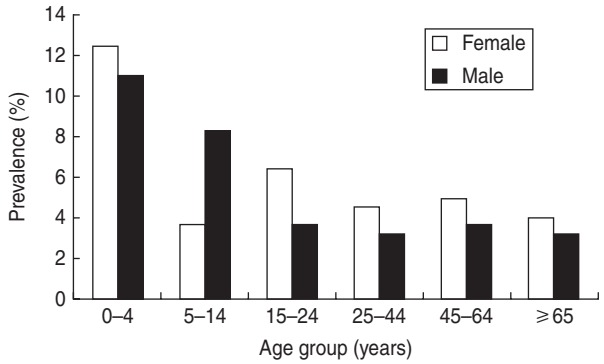

Fig. 2. Monthly prevalence of acute gastrointestinal illness by age and gender, in the 4 weeks prior to interview in Jiangsu province, China, July 2010–June 2011.

respondents were older, more educated and more likely to be male than residents. Age was inversely associated with AGI prevalence. Children aged 0–4 years had the highest prevalence (11·6%) of AGI and the lowest prevalence (3·6%) was observed in the ⩾65 years age group. There were significant differences in AGI prevalence by education and occupation status. Respondents living in a household with at least one person aged <18 years were significantly more likely to have experienced AGI (5·3% *vs.* 3·8%, $P<0·01$, χ^2 test). Percentage of respondents reporting AGI was significantly higher in those who had travelled (6·8%) than in those who had not (4·7%) ($P<0·05$, χ^2 test). In general, women had a higher AGI prevalence than men (Fig. 2). Of the respondents, 78% households had ⩾3 household members, and AGI prevalence was higher (4·9%) in these larger households. There was no statistically significant difference in AGI prevalence between the urban residents and rural residents.

The prevalence of AGI varied by sentinel sites, with the highest in Xinqu (Wuxi prefecture) (15·1%), and the lowest in Taicang (0·5%) ($P<0·01$, χ^2 test). There was a significant seasonal difference in AGI prevalence: summer had the highest prevalence, followed by winter ($P<0·01$, χ^2 test) (Fig. 3).

Multivariable analysis

In the final multivariable regression model, gender, education, season, sentinel site and travel were significantly ($P<0·01$) associated with the occurrence of AGI (Table 2). The odds of AGI was 1·9 times higher in summer than in autumn. Respondents who lived in Xinqu (Wuxi prefecture) ($P<0·01$) or those who had travelled to other city/province were also significantly associated with reporting AGI.

Symptoms and severity

Of the 445 cases who reported illness, 61 (13·7%) respondents experienced both diarrhoea and vomiting. Of the 439 cases with diarrhoea, four (0·9%) had bloody diarrhoea. Of the 445 cases, 17 (3·8%) cases reported more than one episode during the 28-day period.

Overall the mean duration of diarrhoea was 1·8 days (median 1·5 days). Children in the 0–4 years age group had a significantly longer mean duration of diarrhoea (3·4 days) than other age groups ($P<0·01$, ANOVA). On the worst day of symptoms, cases reported diarrhoea an average of 4·1 times (range 3–15 times) and vomiting an average of 2·7 times (range 1–10 times). Twenty-three cases indicated that someone else within the household had similar symptoms at the same time.

Suspected cause of illness

Cases were asked to report what they believed was the cause of their illness. Over half (57·1%) of those with AGI suspected their illness had been caused by consuming contaminated food. Of those who suspected that their illness was due to eating contaminated food, 60·2% thought it was food consumed at home.

Healthcare-seeking behaviour

Healthcare-seeking behaviour of cases, medicines used by cases and the source of the medicine are reported in Table 3. A physician was visited by 38·4% of cases. Healthcare-seeking behaviour varied by age; the prevalence of seeking healthcare for AGI was highest (60·0%) in children aged <15 years. Of those who saw a doctor, 39·2% reported providing a stool sample for laboratory testing.

In total, 397 (89·2%) cases took medications to treat or relieve symptoms for their illness. Sixty-five percent (65·2%) of those with acute gastroenteritis were estimated to have taken antibiotics, while 38·9% reported taking antidiarrhoeals. Of those who took medicine, only 42·8% reported that the medication was prescribed by a doctor, 43·1% obtained medicine from the family medicine chest, 21·7% purchased medicine from a pharmacy without prescription. Antibiotics were taken by 77·2% of those who took medicine from the family medicine chest. However, 86 (21·7%) cases were estimated to have taken more than one type of medication to treat or relieve symptoms.

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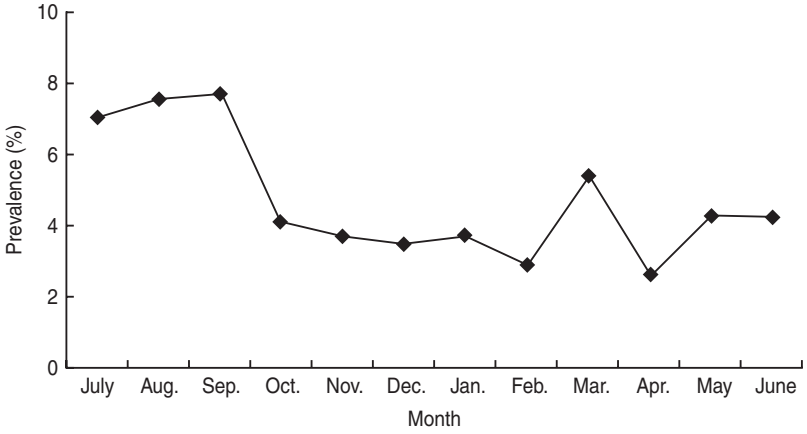

Fig. 3. Monthly prevalence of acute gastrointestinal illness by study month in the 4 weeks prior to interview in Jiangsu province, China, July 2010–June 2011.

Impact on work and school

In total, 9·8% of those with AGI took time off work or school. The mean number of days taken off work was 2·0 days (range 1–5 days). Three children were absent from school as a result of their illness. The mean and median numbers of days of school missed were 1·4 and 1·0, respectively.

Standard case definition comparison

A summary of this study's results using the suggested symptom-based case definition are outlined in Table 4.

DISCUSSION

This study of AGI performed in the community in Jiangsu province, China provides the demographic determinants and burden of AGI. Overall, AGI represented a significant burden in Jiangsu province, we estimated an overall adjusted monthly prevalence of 4·7% and an average of 0·63 AGI episodes/person per year. If extrapolated to the population, this amounts to over 3·6 million cases of AGI every month in Jiangsu, confirming that the magnitude of AGI in Jiangsu province is considerable.

Comparison of AGI rates between countries is complicated by the use of different case definitions and methods in different studies. In this survey, a strict definition was used: diarrhoea of $\geqslant 3$ loose stools in a 24-h period or vomiting with at least one other symptom (abdominal pain/cramps, fever). The estimated rate of AGI in Jiangsu province is comparable to a similar retrospective study conducted in Ireland with 0·6 AGI episodes each year where a similar definition has been used [14]. Other retrospective studies showed different rates: 1·4/person per year in the USA [4], 1·4 in Denmark [8], and 1·3 in Canada [13]. The observed difference could be in the method of measurement or may be due to different exposures based on lifestyle, possibly food or water preparation practices [9]. Recently, Majowicz *et al.* [15] proposed a standard symptom-based case definition for AGI, using this uniform definition is critical for facilitating accurate inter-country comparisons and global burden-of-disease estimates. Using this symptom-based standard definition, we obtained similar results compared to those using the chosen definition in our primary analysis. We thus reported the suggested minimum set of results in this article, in order to facilitate international comparisons.

The estimates of disease burden in the community differ substantially between retrospective and prospective study designs even when using identical case definitions. In a UK study, the retrospective survey estimated disease incidence at 0·55 episodes/person per year and the prospective component at 0·19 [16]. At the time this discrepancy was attributed to recall bias. One example of this is telescoping, with respondents remembering illness events as having occurred more recently than they actually did. But in other studies [6, 17, 18], it is reported that the shorter 7-day recall period yields significantly greater annual estimates compared to the longer 15-day or 30-day recall periods, which is contrary to telescoping, and the true burden of disease is underestimated. Therefore, further investigation and research on this potential bias is necessary.

Table 2. *Final multivariable model of risk factors associated with acute gastrointestinal illness in the 4 weeks prior to interview in Jiangsu province, China, July 2010–June 2011*

	OR	(95% CI)	*P* value
Gender			<0·01
Male	Ref.	Ref.	Ref.
Female	1·43	(1·17–1·75)	<0·01
Education			<0·01
Preschool children	3·53	(2·18–5·71)	<0·01
Illiterate	1·66	(1·11–2·50)	<0·05
Primary	1·10	(0·85–1·43)	0·45
Secondary	Ref.	Ref.	Ref.
Tertiary	0·85	(0·62–1·17)	0·31
University	0·98	(0·66–1·45)	0·90
Season			<0·01
Summer	1·92	(1·49–2·49)	<0·01
Autumn	Ref.	Ref.	Ref.
Winter	0·81	(0·60–1·10)	0·18
Spring	0·82	(0·61–1·11)	0·20
Sentinel site			<0·01
Wuxi	3·13	(2·31–4·26)	<0·01
Xuzhou	0·43	(0·27–0·69)	<0·01
Suzhou	0·30	(0·18–0·49)	<0·01
Taizhou	0·77	(0·52–1·14)	0·19
Jiangyin	Ref.	Ref.	Ref.
Changshu	0·59	(0·39–0·90)	<0·05
Taicang	0·14	(0·07–0·28)	<0·01
Liyang	1·11	(0·77–1·59)	0·57
Yizheng	0·32	(0·19–0·54)	<0·01
Travel			<0·01
Yes	1·80	(1·21–2·69)	<0·01
No	Ref.	Ref.	Ref.

OR, Odds ratio; CI, Confidence interval.

Table 3. *Frequency of hospital consultation and medicine use by cases of acute gastrointestinal illness (n=445) in the 4 weeks prior to interview in Jiangsu province, China, July 2010–June 2011*

Variable	No. of cases (%)
Sought medical care (*n*=445)	
Yes	171 (38·4)
No	274 (61·6)
Submitted a stool sample stool (*n*=171)	
Yes	67 (39·2)
No	104 (60·8)
Took medicine (*n*=445)	
Yes	397 (89·2)
No	48 (10·8)
Type of medicine (*n*=397)*	
Antibiotics	290 (73·0)
Antidiarrhoeals	173 (43·6)
Analgesics	8 (2·0)
Antipyretics	5 (1·3)
Antacids	2 (0·5)
Other	5 (1·3)
Unknown	9 (2·3)
Location of medicine purchase (*n*=397)*	
Family medicine chest	171 (43·1)
Hospitals with prescription	170 (42·8)
Pharmacy	86 (21·7)
Other	7 (1·8)

* Because some people took more than one type of medication and some cases visited more than one location, the total percentage may exceeds 100%.

The gender distribution of AGI in our study is similar to that found in other reports [7, 9]. The higher rate of AGI in females may be due to differences in routes of exposure such as food preparation in the kitchen. We observed significantly higher rates of AGI in children aged <5 years, and lower rates in adults aged ⩾65 years, which is consistent with other studies [13, 19, 20]. The reasons for this increase in children may be due to the naive immune system in children of younger ages, and children aged <5 years being susceptible to rotavirus-infection diarrhoea [21–23]. Although the older group has the lowest AGI rate, they may suffer from higher morbidity and mortality when infected. In other studies, distribution of AGI is reported to have a bimodal distribution [6, 13], with bacterial gastroenteritis tending to peak in the summer [24, 25], while viral gastroenteritis, which may be more common, tending to peak during the winter months [26]. Moreover, seasonality of AGI was observed in this study; a bimodal distribution was observed, with peaks in September and March. In Jiangsu province, Xinqu (Wuxi prefecture) had the highest level of AGI. It is probable that the highly polluted Tai lake, which is the source of drinking water in Wuxi, contributes to this increased risk of AGI in Wuxi prefecture.

In the present study, we found that AGI prevalence decreased with increasing levels of education. Those that had not yet reached school age and the illiterate were more likely to report illness. This may be due to higher AGI rates in children and different lifestyle factors such as health habits, eating-out patterns or awareness of hygienic conditions. In the multivariable model, respondents who had travelled were 1·8 times more likely to report AGI than those who had not, which is similar to other reported studies [14]. The reason for this increase in people who had travelled

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Table 4. *Descriptive statistics of acute gastrointestinal illness following the proposed standard case definition of gastrointestinal illness in Jiangsu province, China, July 2010–June 2011*

Annual incidence per person-year (95% CI)	0·63 (0·63–0·64)
Annual incidence per person-year in males	0·61
Annual incidence per person-year in females	0·66
Mean age of cases (years)	46
Mean duration of illness (days)*	1·85
Cases with bloody diarrhoea (%)	0·89
Cases who sought medical care (%)	38·26
Cases submitting a stool sample for testing (%)	14·99
Cases with respiratory symptoms (%)†	—
Cases with symptoms still ongoing at time of at interview (%)	4·92

CI, Confidence interval.
* Information on the duration of vomiting was not collected in the survey. Calculated by averaging the duration of illness among those had diarrhoea, regardless of whether the illness was still ongoing at the time of data collection.
† Data not collected. Survey respondents were not asked about respiratory symptoms.

may be due to a greater opportunity of exposure to gastrointestinal pathogens.

Healthcare was sought by 38·4% of respondents with AGI. As disclosed in the present work, young children visited health facilities more often than persons aged $\geqslant$15 years, which is in agreement with a previous study in France [27]. The level of medicine use (89·2%) found in this study was higher than that of the other countries, e.g. Ireland (47·0%) [14], Canada (63·9%) [7], France (76·3%) [27]. Because more persons were treated with antibiotics than submitted a stool specimen and most episodes of gastroenteritis do not require antibiotic therapy [28], it is clear that the results presented here may suggest possible over-prescribing of antibiotics. This is of particular concern, especially in view of the increase in antibiotic-resistant pathogens and the potential complications originating from taking antibiotics [29, 30]. In the present study, self-medication appears to be common, as less than half of the medication used was prescribed by a doctor. The factors affecting the prescription and use of antibiotics require further research.

Limitations of this study are those common to other retrospective studies [6, 9, 18], it is possible that due to recall bias that retrospective studies may result in over- or under-estimates of the true incidence of AGI. Another potential limitation of the study may be that the AGI cases were defined based on self-reported symptoms without pathogen-specific laboratory confirmation. It would be useful to carry out further work to measure the incidence of specific laboratory-confirmed infections in the community. The advantage of this study is that we used a face-to-face interview, which may reach the potential participants who do not have access to a phone. A high response rate of 87% was achieved compared to other telephone surveys looking at the same issues [14, 27, 31].

This is the first population-based study presenting the incidence of community-acquired AGI in Jiangsu province, China over a complete year, which provides much needed information for planning control measures for gastroenteritis in an understudied and underreported part of the world. It demonstrates the substantial health burden of AGI in the region, the distribution of AGI estimates and the associations between AGI and demographic distribution. Further research is needed to estimate the proportion caused by foodborne and other sources, and to identify types of foods associated with AGI.

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DECLARATION OF INTEREST

None.

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