

## Original Paper

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# The impact of COVID-19 pandemic on the incidence of acute gastroenteritis outbreaks in Catalonia (Spain)

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**Abstract**

We carried out a retrospective study of acute gastroenteritis (AGE) outbreaks reported between 1 January 2015 and 31 December 2021 in Catalonia (Spain) to compare the incidence from 2015 to 2019 with that observed from 2020 to 2021. We observed a higher incidence rate of outbreaks during the pre-pandemic period (16.89 outbreaks/1,000,000 person-years) than during the pandemic period (6.96 outbreaks/1,000,000 person-years) (rate ratio (RR) 0.41; 95% confidence interval (CI) 0.34 to 0.51). According to the aetiology of the outbreak, those of viral aetiology decreased from 7.82 to 3.38 outbreaks/1,000,000 person-years (RR 2.31; 95% CI 1.72 to 3.12), and those of bacterial aetiology decreased from 5.01 to 2.78 outbreaks/1,000,000 person-years (RR 1.80; 95% CI 1.29 to 2.52). There was a great reduction in AGE outbreaks in Catalonia. This reduction may have been due to the effect of the nonpharmaceutical measures applied to reduce the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), but the collapse of the healthcare system and epidemiological surveillance services may also have had a strong influence.

**Introduction**

On 11 March 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19), the disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a pandemic. At the beginning of the pandemic, there was great uncertainty about the transmission mechanisms of the virus. Person-to-person contact, respiratory droplet transmission, and fomite-mediated transmission were identified as the most common routes of the spread of SARS-CoV-2. It was considered that the disease could be transmitted through aerosols generated during the manipulation of patients' airways [1], although this mode of transmission was considered of little relevance beyond clinical settings [2]. Based on these data, the main WHO recommendation was the implementation of droplet and contact transmission prevention measures, including hand hygiene [2]. Subsequently, outbreaks of COVID-19 were described in restaurants [3] and gyms [4], which led various authors to state the possibility of aerosol transmission [5, 6].

It was expected that measures to prevent COVID-19 transmission would also have an impact on other diseases that share this route of transmission, such as acute gastroenteritis (AGE). Measures to control COVID-19 had already shown a very early impact on the flu season in the Southern Hemisphere (from February to September 2020), with a substantial reduction in the incidence of influenza virus being observed in countries such as Australia, Chile, and South Africa [7].

Huh et al., in the Republic of Korea, studied the consequences of nonpharmaceutical interventions against COVID-19 on the transmission of respiratory infections, comparing the period from January 2016 to January 2020 to the period from February 2020 (when the government decreed the implementation of nonpharmaceutical measures) to July 2020 and observed a reduction of 36.4% in the expected incidence for varicella and 63.4% for mumps during the period in which these measures had been applied compared to the preceding period [8].

The decrease in the reporting of communicable diseases was not only observed for those that shared transmission mechanisms with SARS-CoV-2. In Taiwan (China), between 2019 and 2020, Lai et al. [9] described a 54.8% reduction in the notification of vector-borne diseases, attributing this to less outdoor activity during the pandemic. In contrast, sexually transmitted diseases,

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especially gonorrhoea, showed an increase of 7.2% during the same period, indicating that the lockdown could have been associated with greater sexual activity or risky sexual practices. In Catalonia, no increase was observed in sexually transmitted diseases; instead, a 19% decrease was observed in 2020 and a return to prepandemic levels in 2021 [10, 11].

Globally, in 2019, diarrhoea was the eighth leading cause of death at all ages [12]. In 2017, there were approximately 1.7 billion cases of AGE among children [13]. In 2018, one in nine deaths among children was due to diarrhoea [14], and in 2019, AGE caused 370,000 deaths among children under 5 years of age, making it the second leading cause of death in this age group [15]. A viral aetiology is the main cause of AGE, and it is estimated that norovirus is responsible for 90% of viral gastroenteritis outbreaks [16].

The main mode of transmission of viral AGE is person-to-person, although transmission by common vehicles (food or water) is also feasible [17]. Petrianni *et al.* [18], in a meta-analysis carried out in 2014 that included 40 outbreaks and 18 surveillance studies of AGE due to norovirus, observed that the degree of intense contact between workers and nursing home dwellers was associated with the risk of becoming ill and that attack rates were higher among residents with a higher degree of dependence.

All this justifies investigating whether COVID-19 pandemic has influenced the incidence of AGE outbreaks and our objective in this study is to compare the incidence rate of AGE outbreaks in Catalonia from 2015 to 2019 (prepandemic period) with that observed between 2020 and 2021 (pandemic period).

## Materials and methods

A retrospective study of AGE outbreaks reported between 1 January 2015 and 31 December 2021 was conducted in Catalonia, an area in northeastern Spain with a population of 7,543,825 inhabitants as of January 2018 [19].

Outbreaks of any aetiology must be reported to the Public Health Agency of Catalonia, which carries out an epidemiological study to determine the causes and establish control measures. In the city of Barcelona, these activities are carried out by the Barcelona Public Health Agency with the same procedure.

## Definitions

AGE was defined as a sudden onset of diarrhoea that may also present nausea, vomiting, abdominal pain, or fever. An AGE outbreak was defined as the involvement of two or more epidemiologically related people, either by person-to-person contact or by a common exposure.

Closed and semiclosed institutions are those in which people share the space with other users of the same centre for a considerable part of their time and in which mobility to leave and/or enter the centre has certain restrictions (for example, nursing homes, health institutions, or schools).

Two periods were considered: a first period from 2015 to 2019 (prepandemic period) and a second period from 2020 to 2021 (pandemic period).

## Data collection and management

Data were collected by technicians from the Epidemiological Surveillance Services of the Catalan Public Health Agency and the Barcelona Public Health Agency.

For each outbreak, the number and main characteristics of all known exposed people were recorded, and those who had clinical manifestations or microbiological confirmation were classified as cases. The following variables were included: mode of transmission, setting, number of exposed people, number of affected individuals, and aetiology.

Data collection and cleaning were performed using the Access 12.0 database manager of the MS Office 2013 software package (Microsoft, USA), and a statistical analysis was performed using the PASW Statistics 18.0.2 statistical package (IBM Corporation, USA).

## Aetiological confirmation

The aetiological confirmation of outbreaks was carried out by collecting stool samples and their subsequent microbiological analysis at the Vall d'Hebron University Hospital Laboratory and Barcelona Public Health Agency Laboratory.

The diagnostic tests performed to confirm the aetiology of the outbreak were determined by the clinical presentation. In outbreaks for which a viral aetiology was suspected, a real-time RT-PCR was performed. If a bacterial aetiology was suspected, culture and/or determination of preformed toxins were performed. To determine the presence of parasites, a direct smear examination of stool samples was performed.

## Statistical analysis

The outbreak rate per 1,000,000 person-years for each period was calculated as the quotient of the number of AGE outbreaks divided by the population in the middle of the period studied multiplied by the number of years in the stated period.

For lockdown weeks, this rate was calculated as the ratio of AGE outbreaks during the weeks from 14 March 2020, to 24 June 2020, or the same weeks in prepandemic years and the corresponding number of person-years.

A case was any person who met the criteria of having symptoms compatible with gastroenteritis and who had an epidemiological link with the outbreak. The attack rate was defined as the total number of new cases of AGE divided by the total exposed population. Transmission by common vehicles was considered in outbreaks in which the transmission mechanism was mediated by food or water.

The rate ratio (RR) and its 95% confidence interval (CI) were calculated to compare incidence rates and attack rates in the pandemic period to those in the prepandemic period.

To calculate the statistical significance between the proportions of outbreaks with common vehicle transmission in the two periods (prepandemic and pandemic), a two-tailed chi-squared test with Yates' continuity correction was performed.

The mean number of people exposed in outbreaks with a viral aetiology and in those with a bacterial aetiology that occurred in the prepandemic period was compared with the mean number of people exposed in the pandemic period by Student's *t*-test for the difference between means and its 95% CI.

## Institutional review board statement

This study was conducted according to the guidelines of the Declaration of Helsinki, regulations of the Public Health Agency of Catalonia, and ethical protocols established and was approved by

the University of Barcelona Bioethics Commission (Institutional Review Board IRB00003099) on 12 April 2016.

### Informed consent statement

The authors declare that the Bioethics Committee of the University of Barcelona waived the requirement for informed consent.

All data used in the analysis were collected during routine public health surveillance activities as part of the legislated mandate of the Health Department of Catalonia, which is officially authorized to receive, clean, and temporarily store personal data in the case of infectious diseases. All data were fully anonymized. All study activities formed part of the public health surveillance tasks. The law regulates these activities, and informed consent was not deemed necessary.

## Results

### Incidence of outbreaks during the study period

During the entire study period, 742 AGE outbreaks were reported: 105 outbreaks in the pandemic period (6.96 outbreaks/1,000,000 person-years) and 637 outbreaks in the prepandemic period (16.88 outbreaks/1,000,000 person-years). RR for the pandemic period versus the prepandemic period was 0.41 (95% CI 0.34 to 0.51). The incidence rate was 3.47 outbreaks/1,000,000 person-years in 2020 and 10.47 outbreaks/1,000,000 person-years in 2021 (Table 1).

Lockdown weeks (from 14 March 2020, to 24 June 2020) were compared with the same weeks of the prepandemic period, and the incidence rates were 1.42 outbreaks/1,000,000 person-years and 19.73 outbreaks/1,000,000 person-years, respectively (RR 0.07; 95% CI 0.02 to 0.23) (Table 2).

### Aetiology of outbreaks

In 346 outbreaks, the aetiology was determined to be viral (97.4% norovirus, 2.02% rotavirus, and 0.58% other viruses); 231 outbreaks

had a bacterial aetiology (44.59% *Salmonella*, 13.85% *Shigella*, 11.69% *Clostridium perfringens*, 10% *Staphylococcus aureus*, 4.32% *Bacillus cereus*, 4.76% *Campylobacter*, and 10.82% other bacteria); 52 outbreaks were due to neither bacterial nor viral causes (41 histamine outbreaks, 2 *Cryptosporidium*, 1 *Trichinella spiralis*, and 8 due to toxic mushroom ingestion, Jimsonweed poisoning, or beta-agonists); and in 113 outbreaks, the aetiology was not identified (Figure 1).

During the entire period studied, norovirus was the most frequently identified aetiological agent, causing 53.58% (337/629) of the outbreaks with a known aetiology.

A decrease in the incidence rate of outbreaks during the pandemic period compared to the prepandemic period was observed for all aetiologies. Among those of viral aetiology, the incidence rate was 3.38 outbreaks/1,000,000 person-years in the pandemic period and 7.82 outbreaks/1,000,000 person-years in the prepandemic period (RR 0.43; 95% CI: 0.32 to 0.58). Among those of bacterial aetiology, the incidence rate was 2.78 outbreaks/1,000,000 person-years in the pandemic period and 5.01 outbreaks/1,000,000 person-years in the prepandemic period (RR 0.56; 95% CI: 0.40 to 0.78).

### Transmission mode

During the pandemic period, transmission by common vehicles accounted for 62 outbreaks (59.05%), and during the prepandemic period, this mode of transmission accounted for 348 outbreaks (54.63%). No significant differences were observed between these proportions ( $p = 0.46$ ).

The incidence rate of outbreaks with common vehicle transmission was 4.11 outbreaks/1,000,000 person-years for the pandemic period versus 9.23 outbreaks/1,000,000 person-years for the prepandemic period (RR 0.45; 95% CI 0.34 to 0.58). For outbreaks with person-to-person transmission, these rates were 2.85/1,000,000 person-years and 7.66/1,000,000 person-years, respectively (RR 0.37; 95% CI 0.27 to 0.51).

**Table 1.** Reported outbreaks according to aetiology and year of notification

Year	Viral aetiology		Bacterial aetiology		Protozoal aetiology		Food poisoning		Unknown		All outbreaks	
	Number of outbreaks	Rate <sup>a</sup>	Number of outbreaks	Rate <sup>a</sup>	Number of outbreaks	Rate <sup>a</sup>	Number of outbreaks	Rate <sup>a</sup>	Number of outbreaks	Rate <sup>a</sup>	Number of outbreaks	Rate <sup>a</sup>
2015	70	9.28	33	4.37	0	0.00	5	0.66	34	4.51	142	18.82
2016	65	8.62	39	5.17	0	0.00	11	1.46	26	3.45	141	18.69
2017	57	7.56	37	4.90	1	0.13	15	1.99	19	2.52	129	17.10
2018	58	7.69	43	5.70	2	0.27	7	0.93	17	2.25	127	16.83
2019	45	5.97	37	4.90	0	0.00	7	0.93	9	1.19	98	12.99
2020	8	1.06	11	1.46	0	0.00	3	0.40	4	0.53	26	3.45
2021	43	5.70	31	4.11	0	0.00	1	0.13	4	0.53	79	10.47
Total	346	6.55	231	4.37	3	0.06	49	0.93	113	2.14	742	14.05
2020–2021	51	3.38	42	2.78	0	0.00	4	0.27	8	0.53	105	6.96
2015–2019 (ref)	295	7.82	189	5.01	3	0.08	45	1.19	105	2.78	637	16.89
RR (95%CI) <sup>b</sup>	0.43 (0.32–0.58)		0.56 (0.40–0.78)		NC		0.22 (0.08–0.62)		0.19 (0.09–0.39)		0.41 (0.34–0.51)	

Abbreviation: NC, not calculable.

<sup>a</sup>Number of outbreaks per million person-years.

<sup>b</sup>Rate ratio and 95% confidence interval taking the rate of the period 2015–2019 as reference values.

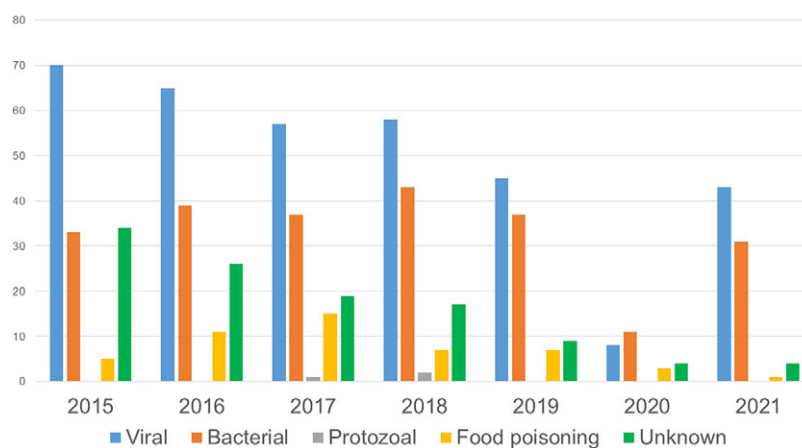
**Table 2.** AGE outbreaks according to the mode of transmission in the pre-pandemic and pandemic periods and during lockdown weeks

Period of outbreak occurrence	Common vehicle transmission						Person-to-person transmission		All outbreaks	
	Foodborne		Waterborne		All		Outbreaks	Rate <sup>a</sup>	Outbreaks	Rate <sup>a</sup>
	Outbreaks	Rate <sup>a</sup>	Outbreaks	Rate <sup>a</sup>	Outbreaks	Rate <sup>a</sup>				
2015	65	8.62	3	0.40	68	9.01	74	9.81	142	18.82
2016	65	8.62	12	1.59	77	10.21	64	8.48	141	18.69
2017	73	9.68	3	0.40	76	10.07	53	7.03	129	17.10
2018	74	9.81	1	0.13	75	9.94	52	6.89	127	16.83
2019	51	6.76	1	0.13	52	6.89	46	6.10	98	12.99
2020	21	2.78	0	0.00	21	2.78	5	0.66	26	3.45
2021	38	5.04	3	0.40	41	5.43	38	5.04	79	10.47
Total	387	7.33	23	0.44	410	7.76	332	6.29	742	14.05
2021–2022	59	3.91	3	0.20	62	4.11	43	2.85	105	6.96
2015–2019	328	8.70	20	0.53	348	9.23	289	7.66	637	16.89
RR (95%CI) <sup>b</sup>	0.45 (0.34 to 0.59)		3.38 (0.11 to 1.26)		0.45 (0.34 to 0.58)		0.37 (0.27 to 0.51)		0.41 (0.34 to 0.51)	
From 14 March 2020, to 24 June 2020	3	9.96	0	0	3	1.42	0	NC	3	1.42
From 14 March to 24 June 2015–2019	105	1.42	6	0.57	109	10.34	99	9.39	208	19.73
RR (95%CI) <sup>b</sup>	0.14 (0.05 to 0.45)		NC		0.14 (0.04 to 0.43)		NC		0.07 (0.02 to 0.23)	

Abbreviation: NC, not calculable.

<sup>a</sup>Outbreak rate per 1,000,000 person-years.

<sup>b</sup>Reference: 2015 to 2019 values.

**Figure 1.** Number of reported outbreaks of AGE according to aetiology. Catalonia, 2015 to 2021.

### Attack rates globally and by transmission mode, setting, and aetiology

In the pandemic and pre-pandemic periods, the global attack rates were 33.84 and 28.00, respectively (RR 1.21; 95% CI 1.17 to 1.25).

RR in person-to-person transmission outbreaks was 1.58 (95% CI 1.50 to 1.66) and 0.82 (95% CI 0.78 to 0.87) in common vehicle transmission outbreaks.

In closed or semiclosed institutions, the attack rate was higher during the pandemic period than during the pre-pandemic period for all modes of transmission (RR 1.36; 95% CI: 1.31 to 1.41). In outbreaks in the community setting, the attack rate was lower during the pandemic period than during the pre-pandemic period

in common vehicle transmission outbreaks (RR 0.60; 95% CI 0.54 to 0.66) but not for person-to-person transmission outbreaks (RR 2.68; 95% CI 2.00 to 3.59) (Table 3).

The attack rate was higher during the pandemic period than during the pre-pandemic period in both viral outbreaks (RR 1.22; 95% CI 1.16 to 1.27) and bacterial outbreaks (RR 1.16; 95% CI 1.09 to 1.24) (Table 4).

The median, range, mode, mean, and standard deviation of viral and bacterial outbreaks for exposed individuals and cases in the pandemic and pre-pandemic periods are shown in Supplementary Table S1. When comparing the pandemic and pre-pandemic periods, significant differences were observed in the mean numbers of exposed people ( $p = 0.02$ ) and confirmed cases ( $p < 0.001$ ).

**Table 3.** Attack rate and rate ratio in the prepandemic and pandemic periods according to the setting and mode of transmission of the outbreak

Setting	Transmission mode	Period	Number of outbreaks	Number of cases	All exposed	AR (%)	RR <sup>a</sup> (95%CI)
Closed and semiclosed facilities <sup>b</sup>	Person to person	Pandemic	37	1,220	3,447	35.39	1.50 (1.42 to 1.57)
		Prepandemic	171	5,122	21,640	23.67	1
	Common vehicle	Pandemic	19	897	2,674	33.55	1.08 (1.02 to 1.16)
		Prepandemic	54	2,165	6,993	30.96	1
	All	Pandemic	56	2,117	6,121	34.59	1.36 (1.31 to 1.41)
		Prepandemic	225	7,287	28,633	25.45	1
Community setting	Person to person	Pandemic	6	23	46	50.00	2.68 (2.00 to 3.59)
		Prepandemic	118	1,172	6,279	18.67	1
	Common vehicle	Pandemic	43	289	1,011	28.59	0.60 (0.54 to 0.66)
		Prepandemic	294	3,181	6,690	47.55	1
	All	Pandemic	49	312	1,057	29.52	0.88 (0.80 to 0.97)
		Prepandemic	412	4,353	12,969	33.56	1
All outbreaks	Person to person	Pandemic	43	1,243	3,493	35.59	1.58 (1.50 to 1.66)
		Prepandemic	289	6,294	27,919	22.54	1
	Common vehicle	Pandemic	62	1,186	3,685	32.18	0.82 (0.78 to 0.87)
		Prepandemic	348	5,346	13,683	39.07	1
	All	Pandemic	105	2,429	7,178	33.84	1.21 (1.17 to 1.25)
		Prepandemic	637	11,640	41,602	28.00	1

Abbreviations: AR, attack rate; RR, rate ratio.

<sup>a</sup>Rate ratio taking the prepandemic period (2015–2019) as reference values.

<sup>b</sup>Nursing homes, health institutions, schools, and summer camps.

**Table 4.** Attack rate (%) and rate ratio according to the mode of transmission in the outbreaks of viral and bacterial aetiology in the prepandemic and pandemic periods

Period	Viral etiology			Bacterial etiology		
	Common vehicle	Person to person	All outbreaks	Common vehicle	Person to person	All outbreaks
2020–2021	AR (Cases/exposed)	AR (Cases/exposed)	AR (Cases/exposed)	AR (Cases/exposed)	AR (Cases/exposed)	AR (Cases/exposed)
2020–2021	27.05 (267/987)	35.46 (1,183/3,336)	33.54 (1,450/4,323)	33.18 (882/2,658)	36.51 (23/63)	33.26 (905/2,721)
2015–2019	42.63 (3,192/7,487)	22.19 (4,460/20,997)	27.57 (7,852/28,484)	33.29 (1,448/4,350)	21.65 (632/2,919)	28.61 (2,080/7,269)
RR (95%CI) <sup>a</sup>	0.63 (0.57 to 0.71)	1.60 (1.52 to 1.68)	1.22 (1.16 to 1.27)	1.00 (0.93 to 1.07)	1.69 (1.21 to 2.35)	1.16 (1.09 to 1.24)

Abbreviations: AR, attack rate; RR, rate ratio.

<sup>a</sup>Rate ratio taking the prepandemic period (2015–2019) as reference values.

## Discussion

In our study, we observed a decrease in the incidence rate of AGE outbreaks during the COVID-19 pandemic in Catalonia. This decrease was probably due to multiple factors. Aemistead et al. [20] described a 52% decrease in AGE outpatient encounters in 2020 in Colorado (United States) compared to 2017–2019 and stated that the increased use of telemedicine in the pandemic period may have impacted the frequency of stool specimen submission for enteric pathogen testing. Siso et al. [21] described decreases in diagnoses of chronic diseases of up to 50% in Barcelona (Spain) in relation to the prepandemic period. Both authors noted that new consultation models, with a decrease in face-to-face visits and an increase in telemedicine, could have contributed to these phenomena, especially the noncollection of samples for the aetiological diagnosis of AGE. The Catalonia Health Report of 2021 also

indicated that there was a significant decrease in the percentage of people who were attended by health services in Catalonia in 2020 and 2021 compared to 2019 [11]. Other authors have observed a decrease in the incidence of AGE. Hatun et al. [22] studied the incidence of AGE among children aged 0 to 17 years in Massachusetts from weeks 13 to 18 of 2019 and in the same weeks in 2020 (weeks after the introduction of social distancing measures), observing a decrease in the incidence from 15/100,000 children in 2019 to 1.8/100,000 children in 2020. The authors considered that this decrease could be attributed both to a real decrease in incidence and to a lower frequency of consultations with health services.

Ando et al. [23], in a study of enteric viruses in wastewater carried out between 2018 and 2023 in Sapporo (Japan), observed that after May 2020, the identification of sapovirus and rotavirus A and the concentration of norovirus GII decreased. Lennon et al.



[24] compared the months of lockdown in the United States in 2020 with the same months in 2019 and observed a reduction in norovirus outbreaks of 90.57%. Douglas *et al.* [25] observed a decrease of 85% in the reports of norovirus to the systems that monitor the activity of this virus in England during the pandemic period and pointed out the risk that the paucity of surveillance data on norovirus activity and circulating strains would result in a potential strain replacement event that was not being monitored as effectively as prior to the emergence of COVID-19.

The reduction in the incidence rate of outbreaks in the pandemic period compared to the prepandemic period was greater for outbreaks of viral aetiology than for those of bacterial aetiology. The greater reduction in the incidence of outbreaks of viral aetiology compared to bacterial outbreaks may be related to the fact that nonpharmacological measures had a greater impact on the transmission mechanisms of viral outbreaks. Other authors have also observed a greater decrease in outbreaks of viral aetiology than in bacterial outbreaks. Ondrikova *et al.* [26] described that the impact of the pandemic was more pronounced in laboratory reports of norovirus than laboratory reporting of *Campylobacter* in England during 2020 compared to 2015–2019 data, indicating as possible causes the prioritization of the analysis of bacterial AGE samples and that the greater severity of *Campylobacter* infection entailed a greater frequency of consultation with health services. Wang *et al.* [27] observed an annual average of 5,521 cases of AGE from 2012 to 2019 in China and only 1,772 cases in 2020, with this decrease occurring for all viral and bacterial AGE cases except those caused by nontyphoid *Salmonella* and *Campylobacter*, which increased by 66.53% and 90.48%, respectively. Ahn *et al.* [28] compared the incidence rates of AGE cases in Korea from March to August 2020 with those of the previous two years and observed a decrease in the rates of viral gastroenteritis and an increase in the rates of *Campylobacter* and *C. perfringens*. Mark *et al.* [29] observed a significant decrease in positive samples among patients with viral AGE but not among those with bacterial AGE in Germany. The decrease in mean samples tested for viruses in the pandemic period compared to the prepandemic period was 40.6%, while for samples tested for bacteria the decrease was 27.1%. One possible explanation is that since viral aetiological symptoms are usually less severe than those of a bacterial aetiology, during the pandemic period, people with viral symptoms either did not consult the health system or were tested less frequently than in the prepandemic period.

We also observed this decrease in outbreak rates during the pandemic period when separately analyzing outbreaks transmitted by a common vehicle or by person-to-person transmission, as well as when comparing lockdown weeks with the same weeks of the prepandemic years.

The decrease in the rate of AGE outbreaks in Catalonia, both in common vehicle transmission outbreaks and in person-to-person transmission outbreaks, seems logical since during the pandemic period there was a substantial decrease in social events and reduced use of collective catering services.

The decrease in outbreak incidence rates detected by us and other authors [30] was not accompanied by a decrease in attack rates in such outbreaks.

The attack rate was higher in the pandemic period than in the prepandemic period for all outbreaks and in outbreaks of person-to-person transmission but not in common vehicle transmission outbreaks. Attack rates in community-based outbreaks were higher in the prepandemic period for outbreaks with person-to-person transmission, but in outbreaks with common vehicle transmission the attack rates were higher in the

prepandemic period. Other authors have also observed higher attack rates in AGE outbreaks during the pandemic period. Lu *et al.* [31] described attack rates of 5.85% in norovirus AGE outbreaks in Guangzhou (China) in 2020 and 4.83% from 2015 to 2019. These authors suggest that efforts dedicated to the control of COVID-19 would have occupied the necessary material and human resources to respond to other diseases, such as diarrhoea. This suggests that, despite the nonpharmacological preventive measures adopted to reduce the transmission of SARS-CoV-2, there were circumstances during the pandemic period that favoured a higher transmission of AGE by direct contact, especially in viral outbreaks, which need a lower infective dose (a mean of 18 viral particles for norovirus [32] versus 106 particles for *Salmonella* [33]).

It is striking that in closed and semiclosed centres, the attack rates were higher during the pandemic period for both modes of transmission. In community-wide outbreaks, the overall attack rates and transmission by common vehicles were lower in the pandemic period. This could indicate a lower impact of nonpharmacological measures in closed and semiclosed institutions. Another possible explanation could be the lack of human resources in closed and semiclosed centres being significantly affected by COVID-19. Before the pandemic, the average staff/user ratio in Spanish residences was below the recommendations issued by the administration. In some centres, sick leave due to COVID-19 affected 75% of the staff [34]. Additionally, in Canada in 2020, 86% of long-term care facilities (LTCFs) and 71% of nursing homes reported an increase in absenteeism [35].

The mean numbers of exposed and sick people were higher during the pandemic period than during the prepandemic period. Some authors have pointed out that the time elapsed from the notification of the outbreak to the initiation of control measures was longer during the pandemic, and this could have had an impact on a greater number of affected people [31].

Our work has some limitations. We could not rule out that the differences observed in the attack rates were because during the pandemic epidemiological services were overwhelmed and had less capacity to study outbreaks and determine the number of individuals exposed previously.

Thus, Durant *et al.* [36] studied the impact the pandemic had on the activity of clinical laboratories in the United States and Canada. Comparing the weeks before tests for SARS-CoV-2 available with the weeks after, they observed a decrease in all types of clinical tests requested, with a decrease of 53.9% for microbiological tests and 26.8% for virological tests. Additionally, in Catalonia, the Microbiology Notification System had, in 2020, a decrease of 43.5% (95% CI 42.5 to 44.4%) in the identification and reporting of enteritis-producing agents of all aetiologies compared to 2019 [37]. The decrease in this laboratory activity may result in the emergence of new strains or the replacement of existing strains may go unnoticed and affect the most susceptible groups. This lower intervention capacity of health services was also observed in the control of other diseases, such as tuberculosis contact tracing [38] or cancer diagnoses [11]. Another limitation was the low number of reported outbreaks in 2020, which made it difficult to obtain statistically significant results in any of the analyses.

## Conclusion

The COVID-19 pandemic brought a substantial reduction in notifications of AGE outbreaks. This reduction can be attributed to a lower incidence due to the nonpharmaceutical measures

implemented to prevent the transmission of SARS-CoV-2 or to a reduction in the diagnosis and notification of outbreaks to epidemiological surveillance services. In addition, changes in the care model, social changes (telemedicine, teleworking), cultural changes, and interpersonal relationships may have played an important role in this reduction. The reduction was greater in 2020, and in 2021, a return to a normal incidence began that affected outbreaks of any aetiology.

It is also possible that affected people did not consult overloaded health services. The lower capacity of surveillance services to investigate reported outbreaks, prioritizing larger outbreaks, may explain the higher attack rate during the pandemic period. Diminished surveillance of the aetiological agents that cause AGE can have a negative impact on the health of the population since agents with a more severe impact on vulnerable groups can go undetected.

The greater reduction in the incidence of outbreaks with a viral aetiology compared to bacterial outbreaks may be related to the fact that nonpharmaceutical measures had a greater impact on the transmission mechanisms of viral outbreaks. Other authors have also observed a greater decrease in outbreaks with a viral aetiology.

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