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Childcare and School Acute Gastroenteritis Outbreaks: 2009–2020

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Abstract

OBJECTIVES: Acute gastroenteritis (AGE) outbreaks commonly occur in congregate settings, including schools and childcare facilities. These outbreaks disrupt institutions, causing absences and temporary facility closures. This study analyzed the epidemiology of school and childcare AGE outbreaks in the United States.

METHODS: We analyzed AGE outbreaks occurring in kindergarten to grade 12 schools and childcare facilities reported via the National Outbreak Reporting System in the United States from 2009 to 2019 and compared this information to 2020 data. Outbreak and case characteristics were compared using the Kruskal-Wallis rank sum test, χ^2 goodness-of-fit test, and Fisher exact test.

RESULTS: From 2009 to 2019, there were 2623 school, 1972 childcare, and 38 school and childcare outbreaks. School outbreaks were larger (median, 29 cases) than childcare outbreaks (median, 10 cases). Childcare outbreaks were longer (median, 15 days) than school outbreaks (median, 9 days). Norovirus (2383 outbreaks; 110 190 illnesses) and *Shigella* spp. (756 outbreaks; 9123 illnesses) were the most reported etiologies. Norovirus was the leading etiology in schools; norovirus and *Shigella* spp. were dominant etiologies in childcare centers. Most (85.7%) outbreaks were spread via person-to-person contact. In 2020, 123 outbreaks were reported, 85% in the first quarter.

CONCLUSIONS: Schools and childcare centers are common AGE outbreak settings in the United States. Most outbreaks were caused by norovirus and *Shigella* spp. and spread via person-

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to-person transmission. Fewer outbreaks were reported in 2020 from the COVID-19 pandemic. Prevention and control efforts should focus on interrupting transmission, including environmental disinfection, proper handwashing, safe diapering, and exclusion of ill persons.

INTRODUCTION

Approximately 179 million cases of acute gastroenteritis (AGE) occur in the United States every year[1]; outbreaks of AGE commonly occur in congregate settings, where many people gather in close proximity, including schools and childcare centers.[2,3] In the United States, there are 130 930 primary and secondary schools serving 56.4 million students primarily 5 to 18 years old.[4] Additionally, approximately 230 000 home and center-based childcare programs serve ~10 million children from birth to 5 years old.[5]

With many children in 1 location, the presence of diapered children in childcare facilities, and many shared surfaces, the spread of enteric pathogens can happen quickly in schools and childcare facilities.[6] To prevent the spread of AGE pathogens, guidelines from the American Academy of Pediatrics recommend excluding symptomatic children and staff from school or daycare.[7] Illness control regulations in schools and childcare facilities vary between jurisdictions[8] and, despite these regulations, outbreaks in schools and childcares still occur. AGE outbreaks disrupt childcare and school operations, causing temporary closures of a facility or school district[9] and costing millions of dollars in direct and indirect economic costs.[10] Beginning in March 2020, the unprecedented COVID-19 pandemic led to closures of 95% of schools for in-person learning and two-thirds of childcare centers across the United States, affecting more than 55 million children.[11,12]

To collect information on foodborne, waterborne, and enteric outbreaks in the United States, the Centers for Disease Control and Prevention (CDC) launched the National Outbreak Reporting System (NORS) in 2009, through which state, local, and territorial health departments can report outbreaks.[13] Other studies have published NORS AGE outbreak data in other congregate settings, including camps,[14] colleges and universities,[15] and long-term care facilties.[16] This paper summarizes AGE outbreak characteristics in kindergarten to grade 12 (K–12) schools and childcares reported through NORS from 2009 to 2019 and compares these with outbreaks reported in 2020. In doing so, this paper documents the AGE outbreak burden in these settings and provides data to inform prevention and infection control measures.

METHODS

NORS is a dynamic, voluntary reporting system through which state, local, and territorial health departments in the United States report foodborne and waterborne disease outbreaks and enteric disease outbreaks spread via contact with environmental sources, infected persons or animals, or unknown modes of transmission to the CDC. In NORS, an outbreak is defined as 2 or more cases of similar illness with a common exposure or epidemiologic link.[13]

NORS collects aggregate demographic, epidemiologic, clinical, and laboratory data for each outbreak. All NORS outbreak reports contain the number of primary cases, mode of

transmission, exposure state, and date the first case became ill. Other data are collected when available, including setting, suspected and laboratory-confirmed etiologies, attack rates, case demographics, and symptoms. In NORS, outbreak etiologies are reported based on available laboratory, clinical, or epidemiologic information. Confirmed etiologies have 2 or more cases with laboratory test confirmation; suspected etiologies include those with no testing or with a single positive specimen. If no laboratory testing is available, suspected etiologies can be reported based on clinical and epidemiologic information. When available, the number of cases with an outbreak-associated outpatient medical visit, emergency department visit, hospitalization, or death is collected along with the number of cases for whom this information is available. Mode of transmission is the primary means of pathogen spread; in NORS, person-to-person transmission is defined as direct contact with infected persons, their bodily fluids, or the local environment where both the exposed and infected persons were simultaneously present.[13]

We included AGE outbreaks reported through NORS that occurred at a K–12 school or childcare from January 1, 2009, through December 31, 2020. Study data were extracted from NORS on February 9, 2022. Our analyses focused on outbreaks occurring from 2009 to 2019; 2020 outbreak data are reported separately. Outbreak setting was classified by reviewing reported settings, with additional review of case demographics and comment fields, as necessary. Schools were defined as public or private elementary, middle, or high schools primarily serving grades K–12; childcare centers were defined as center or home-based childcare centers primarily serving children ≤5 years old, including preschools. Outbreaks that occurred at a facility serving preschool and school-age children in a single location (eg, pre-K to grade 6) were classified as “school” outbreaks, whereas outbreaks that affected both a childcare center and separate school location were classified as “both school and childcare” outbreaks. For foodborne outbreaks, the outbreak setting was where the food was prepared or eaten.

Because NORS collects data on nonenteric foodborne and waterborne outbreaks, analysis was restricted to AGE outbreaks. AGE symptoms included bloody stools, diarrhea, gastroenteritis, nausea, vomiting, or abdominal cramps. Outbreaks caused by a non-AGE etiology (eg, *Legionella* spp.) were excluded. Suspected and laboratory-confirmed outbreak etiologies were grouped by genus. Outbreaks with >1 suspected or laboratory-confirmed etiology were classified as multiple etiology outbreaks.

Outbreaks identified as occurring at a university, technical school, or college; in a primary or secondary boarding school; outside of normal school operations (eg, sports tournament, camp, community meeting); or only among staff or faculty (eg, teacher appreciation breakfast) were excluded. Outbreaks where exposure occurred in multiple states were excluded (Supplemental Fig 4).

Analyses were conducted using the R Environment for Statistical Computing (version 4.0.4).[17] Outbreak size, duration, attack rates, and reported symptoms were compared using the Kruskal-Wallis rank-sum test. Outbreak seasonality was assessed using a χ^2 goodness-of-fit test, and outbreak etiologies were compared using the Fisher exact test. Rates of health care utilization for outpatient, emergency department, and hospital visits were calculated

using the number of cases with reported information as a denominator and were compared using Fisher exact test.

RESULTS

Between 2009 and 2020, 42 619 outbreaks were reported through NORS; 5145 (12.1%) reported an outbreak setting of “school/college/university” or “child daycare,” and 4756 (92.4%) met our inclusion criteria (Supplemental Fig 4).

Of these, 4633 outbreaks occurred from 2009 to 2019; 2623 (56.6%) in schools, 1972 (42.6%) in childcare facilities, and 38 (0.8%) in both a school and childcare facility (Table 1). During this period, outbreaks were reported by 49 states, Puerto Rico, and Washington DC. A total of 166 787 cases were reported; 132 557 cases (79.5%) in schools, 29 318 (17.6%) in childcare facilities, and 4912 (2.9%) in a school and childcare outbreak (Table 1).

From 2009 to 2019, most outbreaks (n = 2947, 63.6%) occurred during October through March compared with April through September (P < .001). This fall/winter predominance was most marked among school outbreaks (n = 1904, 72.6%, P < .001) and outbreaks reporting a viral etiology (n=1775, 72.8%, P < .001) (Fig 1). Childcare outbreaks occurred consistently throughout the year (51.6% from October through March), but seasonal variation was observed by etiology: most childcare outbreaks reporting a viral etiology occurred during October through March as compared with April through September (n = 479, 66.5%, P < .001) and a majority reporting a bacterial etiology occurred during April through September compared with October through March (n = 499, 61.8%, P < .001) (Fig 1).

From 2009 through 2019, outbreaks lasted a median of 12 days (interquartile range [IQR]: 6–22). Childcare outbreaks (median, 15 days; IQR: 8–26) lasted significantly longer than school outbreaks (median, 9 days; IQR: 4–18; Table 1) (P < .001). Bacterial outbreaks (median, 19 days; IQR: 10–32) lasted significantly longer than viral outbreaks (median, 10 days, IQR: 5–18) (P < .001). The median number of cases was significantly higher in school outbreaks (29 cases; IQR: 13–63) than childcare outbreaks (10 cases; IQR: 5–20;Table 1) (P < .001).

Person-to-person transmission (n = 3971, 85.7%, Table 2) accounted for most school and childcare outbreaks during 2009 through 2019. Foodborne (n = 123, 2.7%), environmental contamination (n = 14, 0.3%), animal contact (n = 11, 0.2%), and waterborne (n = 10, 0.2%) were uncommon modes of transmission (Table 2). For the remaining outbreaks (n = 504, 10.9%), the mode of transmission could not be determined.

Most school and childcare outbreak reports (n = 3741, 80.7%) during 2009 through 2019 included a suspected or laboratory-confirmed etiology. Nearly one-fifth of outbreaks did not report an etiology (n = 892, 19.3%). Most outbreaks reported a single suspected or laboratory-confirmed viral (n = 2438, 52.6%) or bacterial (n = 1086, 23.4%) etiology; outbreaks caused by a parasite (n = 112, 2.4%), chemical/toxin (n = 6, 0.1%), or that had multiple etiologies (n = 99, 2.1%) accounted for less than 5% of reported outbreaks. Viral etiologies accounted for 65.2% school outbreaks and 36.5% of childcare outbreaks.

Bacterial etiologies were more commonly reported in childcare outbreaks (41.0%) than school outbreaks (9.9%) ($P < .001$) (Table 1).

From 2009 through 2019, norovirus ($n = 2383$, 51.4%) and *Shigella* spp. ($n = 756$, 16.3%) were the most commonly reported pathogens, representing 67.7% of outbreaks. Norovirus was the leading pathogen in school outbreaks ($n = 1689$, 64.4%), whereas norovirus ($n = 686$, 34.8%) and *Shigella* spp. ($n = 537$, 27.2%) were reported at a similar frequency in childcare outbreaks (Table 1). The next most common pathogens included *Escherichia coli* ($n = 138$, 3.0%), *Salmonella* spp. ($n = 138$, 3.0%), and *Cryptosporidium* spp. ($n = 90$, 1.9%), all 3 of which were more commonly reported in childcares outbreaks than in schools (Table 1).

From 2009 to 2019, 1012 (38.6%) school outbreaks and 1051 (53.3%) childcare outbreaks reported attack rate data for both students/attendees and staff. Among outbreaks with complete data, the median attack rate was 15.8% (IQR: 7%–31%) for students/attendees and 7.7% (IQR: 0%–23%) for staff. The median attack rates for childcare attendees (18.9%, IQR: 10%–36%) and childcare staff (13.3%, IQR: 0%–33%) were significantly higher than attack rates for students (12%, IQR: 6%–25%, $P < .001$) and staff (5.2%, IQR: 1%–14%, $P < .001$) in schools.

Most outbreak cases in 2009 through 2019 occurred among students or childcare attendees; a median of 97.1% of cases in school outbreaks were 5 to 19 years old and a median of 80.0% of cases in childcare outbreaks were <5 years old. Most cases reported diarrhea (median, 82.3%; IQR: 40%–100%) or vomiting (median, 75.0%; IQR: 42%–100%). Compared with school outbreaks, a higher percentage of cases childcare outbreaks reported diarrhea (medians, 100% vs. 54.5%, $P < .001$) and a lower percentage reported vomiting (medians, 52.2% vs. 87.0%, $P < .001$).

From 2009 to 2019, 2594 (98.9%) school, 1969 (99.8%) childcare, and 36 (94.7%) school and childcare outbreaks reported 6409 outpatient visits, 1604 emergency department visits, 694 hospitalizations, and 5 deaths. Childcare outbreaks reported higher rates of outpatient visits (24.2 vs. 5.5 per 100 case-patients, $P < .001$), emergency department visits (4.8 vs 1.5 per 100 case-patients, $P < .001$), and hospitalizations (1.8 vs 0.3 per 100 case-patients, $P < .001$) than school outbreaks (Fig 2). Health care utilization varied by pathogen, with bacterial (48.4 outpatient visits per 100 case-patients; 4.6 hospitalizations per 100 case-patients) and parasitic (61.2 outpatient visits per 100 case-patients; 2.4 hospitalizations per 100 case-patients) pathogens having the highest rates of health care utilization across both settings (Fig 2). In our dataset, 5 deaths were reported: 3 in childcare outbreaks (3 different *E coli* O157:H7 outbreaks) and 2 in school outbreaks (a norovirus outbreak and an outbreak with no reported etiology).

The number of outbreaks reported per year ranged from 139 in 2009 to 716 in 2016; 544 outbreaks were reported in 2019 (Fig 3). From 2012 to 2019, an annual median of 532 outbreaks were reported in these settings; by setting, an annual median of 280 school, 230 childcare, and 4 school and childcare outbreaks were reported. In contrast, in 2020, 123 outbreaks (76 school and 47 childcare outbreaks) were reported (Fig 3); 105 (85%) from

January to March 2020. No outbreaks were reported in April, May, August, or December 2020 (Supplemental Fig 5). In 2020, most outbreaks reported norovirus (*n* = 80, 65.0%), followed by *Shigella* spp. (*n* = 10, 8.1%), *E coli* (*n* = 4, 3.2%), *Salmonella* spp. (*n* = 3, 2.4%), and *Staphylococcus* spp. (*n* = 1, 0.8%); 25 outbreaks (20.3%) reported no etiology. Most outbreaks (*n* = 96, 78%) were person-to-person transmission, followed by foodborne (*n* = 2, 1.6%) and unknown (*n* = 25, 20.3%).

DISCUSSION

K–12 schools and childcares are common AGE outbreak settings. During 2009 through 2020, 4756 outbreaks in these settings were reported to CDC through NORS. From 2009 through 2019, 4633 outbreaks were reported (median, 457 outbreaks per year) causing 166 787 cases, 6409 outpatient visits, 1604 emergency department visits, 694 hospitalizations, and 5 deaths. Norovirus and *Shigella* spp. were the most commonly reported etiologies; norovirus caused two-thirds of K–12 school outbreaks, and norovirus and *Shigella* spp. together caused two-thirds of childcare outbreaks. Across settings and etiologies, person-to-person transmission dominated.

In March 2020, almost all K–12 schools and two-thirds of childcare facilities in the United States shut down because of the COVID-19 pandemic.[11,12] Outbreaks reported in these settings through NORS dropped from 544 in 2019 to 123 in 2020; only 18 outbreaks were reported between April and December 2020. Other studies have also shown a sharp decrease in AGE pathogen activity in 2020, coinciding with nonpharmaceutical interventions (eg, social distancing) implemented to prevent the transmission of COVID-19.[18-21] Similar to the 2009 to 2019 outbreaks, most 2020 outbreaks were caused by norovirus and spread via person-to-person transmission. Comparatively, *Shigella* spp. caused fewer 2020 outbreaks, likely because of *Shigella* spp.'s summer seasonality.[22]

Consistent with this study, norovirus and *Shigella* spp. are significant AGE pathogens in young children and adolescents[22,23] and common causes of outbreaks in schools and childcares.[3,6,24-29] Our study period (2009–2020) occurred after US rotavirus vaccine introduction in 2006, after which norovirus became the dominant pediatric viral gastroenteritis etiology in the United States.[30-32] Additionally, our study is larger and covers a longer period and larger geographic area than other studies and may more accurately capture the relative national burden of different school and childcare outbreak etiologies. In comparison, pathogens, such as *E coli, Salmonella* spp., rotavirus, and sapovirus have played a larger role in school and childcare outbreaks reported previously.[33-35]

An analysis of 29 childcare AGE outbreaks in North Carolina attributed 45% of outbreaks to a viral etiology, mostly rotavirus and norovirus, but only 1 outbreak to *Shigella.*[33] In a 2008 systematic review of childcare outbreak reports, *E coli*, *Salmonella* spp., norovirus, and rotavirus were the leading pathogens, with *Shigella* spp. only representing 5% of outbreaks.[34] In our analysis, *Shigella spp.* was the second leading cause of childcare outbreaks; only 7% of outbreaks were caused by other bacterial pathogens and 1% by viral pathogens other than norovirus.

In this study, person-to-person transmission dominated in school and childcare outbreaks, which is consistent with other outbreak reports in these settings[34,36-39] and evidence that norovirus and *Shigella* spp. are predominantly spread via person-to-person transmission.[3,22] A systematic review of childcare outbreaks found person-to-person transmission to be the prominent mode but also found 16% of reported outbreaks were spread via foodborne transmission[34]; many school and childcare outbreak reports in the literature also mainly describe outbreaks spread via foodborne transmission.[2,40-42] However, in our study, <3% of outbreaks were spread via foodborne transmission. Although both norovirus and *Shigella* spp. can be spread via food[43] and cause foodborne disease,[43] our study emphasizes the importance of person-to-person contact as the dominant mode of transmission in both schools and daycares and across both bacterial and viral etiologies.

School outbreaks were larger, shorter, more seasonal, and had fewer health care encounters than childcare outbreaks and were predominately caused by norovirus. Norovirus has a distinct winter seasonality, is characterized by short, mild illness,[23] and can present as vomiting only.[44-46] In the United States, K–12 schools are typically closed for parts of June to August, whereas childcare facilities operate year-round. Conversely, bacterial outbreaks, particularly *Shigella* spp., were more commonly reported in childcare facilities; these pathogens can cause more severe and longer diarrheal disease[22] with less pronounced seasonality.[47,48] Bacterial outbreaks may spread more in childcares because of diapered children, poor hand hygiene, and younger age of the children.[22,49] Additionally, childcare outbreaks may have been more severe because of the younger age and presumably less developed immune systems of childcare attendees.

Although NORS is a national surveillance system gathering timely data on many outbreaks, it has limitations. NORS reporting has increased over time,[3] likely because of increased reporting capacity by health departments. Although the number of reported school and childcare outbreaks also increased over our study period, NORS' limited data collection does not allow us to discern if this is a true increase or a reporting artifact. NORS reporting is also voluntary; not all jurisdictions report all outbreaks through NORS, and some deprioritize reporting of outbreaks spread via person-to-person transmission. For these reasons, this analysis summarized the data on a national level and did not explore any state or regional trends. NORS data likely underrepresent the true number of AGE and person-to-person outbreaks in schools and childcare facilities in the United States, especially from 2009 to 2011 after NORS was initially launched. Additionally, outbreak etiologies can be reported based solely on clinical or epidemiologic data; outbreaks without confirmatory laboratory testing could be misclassified. Given that sapovirus, rotavirus, and astrovirus outbreaks can present similarly to norovirus outbreaks, some outbreaks reporting no etiology or norovirus may have been caused by other pathogens.[50] This analysis did not include secondary cases or transmission outside of the school or childcare center. However, children infected in school and childcare outbreaks can be a source of transmission to household members and contribute to a pathogen's spread in the wider community.[51-53]

Shigella spp. and norovirus vaccines are in development,[22,54] and *Shigella* spp. can be treated with antibiotics.[22] However, nonpharmaceutical interventions, including proper handwashing with soap and water,[55-57] and exclusion of ill children and staff,[58] can prevent

both sporadic and outbreak associated AGE illnesses in these settings.[7,59] Both norovirus and *Shigella* are also known to persist on contaminated surfaces[60]; common surfaces and diapering areas should be routinely cleaned and disinfected with products effective against these pathogens.[61-65] Schools and childcare centers should enforce proper infection control strategies to prevent and control AGE outbreaks and reduce AGE-related absenteeism.

CONCLUSION

Schools and childcare centers are common settings for AGE outbreaks, accounting for a median of 457 outbreaks and 15 779 cases per year in the United States from 2009 to 2019. In 2020, reported AGE outbreaks decreased dramatically to 123 reported outbreaks for the year, correlating with the closure of nearly all K-12 schools and two-thirds of childcare centers because of the COVID-19 pandemic. Schools and childcare centers provide a prime setting for the spread of AGE pathogens, particularly norovirus and *Shigella* spp., through person-to-person contact. Outbreak prevention and control in these settings should focus on handwashing, cleaning and disinfection with effective products, and the exclusion of ill children and staff.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

AGE	acute gastroenteritis
CDC	Centers for Disease Control and Prevention
IQR	interquartile range
K–12	Kindergarten to grade 12
NORS	National Outbreak Reporting System

REFERENCES

1. Scallan E, Griffin PM, Angulo FJ, Tauxe RV, Hoekstra RM. Foodborne illness acquired in the United States–unspecified agents. Emerg Infect Dis. 2011;17(1):16–22 [PubMed: 21192849]
2. Godoy P, Alsedà M, Bartolomé R, et al. Norovirus gastroenteritis outbreak transmitted by food and vomit in a high school. Epidemiol Infect. 2016;144(9):1951–1958 [PubMed: 26759924]
3. Wikswo ME, Roberts V, Marsh Z, et al. Enteric illness outbreaks reported through the National Outbreak Reporting System, United States, 2009-19. Clin Infect Dis. 2022;74(11):1906–1913. [PubMed: 34498027]

4. de Brey C, Snyder TD, Zhang A, Dillow SA. Digest of Education Statistics 2019, 55th edition. National Center for Education Statistics. Available at: https://nces.ed.gov/pubs2021/2021009.pdf. Accessed November 8, 2021
5. U.S. Department of Health & Human Services Office of Child care. The Decreasing Number of Family Child Care Providers in the United States. Updated December 19, 2019. Available at: https://www.acf.hhs.gov/occ/news/decreasing-number-family-child-care-providers-united-states#1. Accessed November 8, 2021
6. Centers for Disease Control and Prevention (CDC). Norovirus outbreak in an elementary school–District of Columbia, February 2007. MMWR Morb Mortal Wkly Rep. 2008;56(51–52):1340–1343 [PubMed: 18172420]
7. American Academy of Pediatrics, American Public Health Association, National Resource Center for Health and Safety in Child Care and Early Education. CFOC Standards Online Database. Aurora, CO; National Resource Center for Health and Safety in Child Care and Early Education; 2020. Available at: https://nrckids.org/CFOC/Database/3.6.1.2. Accessed November 8, 2021
8. Holm SM, Leonard V, Durrani T, Miller MD. Do we know how best to disinfect child care sites in the United States? A review of available disinfectant efficacy data and health risks of the major disinfectant classes. Am J Infect Control. 2019;47(1):82–91 10.1016/j.ajic.2018.06.013 [PubMed: 30172610]
9. Stott B, Gerson WT. Norovirus outbreak grows to 2,800 cases in northern California schools. Infect Dis Children. May 23, 2017. Available at: https://www.healio.com/news/pediatrics/20170523/norovirus-outbreak-grows-to-2800-cases-in-northern-california-schools. Accessed November 8, 2021
10. Bartsch SM, O'Shea KJ, Lee BY. The clinical and economic burden of norovirus gastroenteritis in the United States. J Infect Dis. 2020;222(11):1910–1919 10.1093/infdis/jiaa292 [PubMed: 32671397]
11. Coronavirus and school closures. Education Week. March 6, 2020. Available at: https://www.edweek.org/leadership/map-coronavirus-and-school-closures-in-2019-2020/2020/03. Accessed April 14, 2022
12. Lee EK, Parolin Z. The care burden during COVID-19: a national database of child care closures in the United States. Socius. 2021;7:1–10 10.1177/23780231211032028
13. Centers for Disease Control and Prevention. About National Outbreak Reporting System (NORS). Updated November 4, 2019. Available at: https://www.cdc.gov/NORS/about.html. Accessed July 2, 2021
14. Kambhampati AK, Marsh ZA, Hlavsa MC, et al. Prevention and control of youth camp-associated acute gastroenteritis outbreaks. J Pediatric Infect Dis Soc. 2019;8(5):392–399 10.1093/jpids/piy068 [PubMed: 30085136]
15. Bhatta MR, Marsh Z, Newman KL, et al. Norovirus outbreaks on college and university campuses. J Am Coll Health. 2020;68(7):688–697 10.1080/07448481.2019.1594826 [PubMed: 31084526]
16. Calderwood LE, Wikswo ME, Mattison CP, et al. Norovirus outbreaks in long-term care facilities in the United States, 2009-2018: a decade of surveillance. Clin Infect Dis. 2022;74(1):113–119 10.1093/cid/ciab808 [PubMed: 34523674]
17. R Core Team. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/.
18. Kraay ANM, Han P, Kambhampati AK, Wikswo ME, Mirza SA, Lopman BA. Impact of nonpharmaceutical interventions for severe acute respiratory syndrome coronavirus 2 on norovirus outbreaks: an analysis of outbreaks reported by 9 US states. J Infect Dis. 2021;224(1):9–13 10.1093/infdis/jiab093 [PubMed: 33606027]
19. Burnett E, Parashar UD, Winn A, Tate JE. Trends in rotavirus laboratory detections and internet search volume before and after rotavirus vaccine introduction and in the context of the COVID-19 pandemic–United States 2000-2021 [published online ahead of print February 20, 2022]. J Infect Dis. 10.1093/infdis/jiac062
20. Armistead I, Tran A, White AE, Wilson E, Scallan Walter EJ. Trends in outpatient medical-care seeking for acute gastroenteritis during the COVID-19 pandemic, 2020. Foodborne Pathog Dis. 2022;19(4):290–292 10.1089/fpd.2021.0099 [PubMed: 35020464]

21. Chan MC. Return of norovirus and rotavirus activity in winter 2020–21 in city with strict COVID-19 control strategy, China. Emerg Infect Dis. 2022;28(3):713–716 10.3201/eid2803.212117 [PubMed: 35049493]
22. Kotloff KL, Riddle MS, Platts-Mills JA, Pavlinac P, Zaidi AKM. Shigellosis. Lancet. 2018;391(10122):801–812 10.1016/S0140-6736(17)33296-8 [PubMed: 29254859]
23. Hall AJ, Lopman BA, Payne DC, et al. Norovirus disease in the United States. Emerg Infect Dis. 2013;19(8):1198–1205 10.3201/eid1908.130465 [PubMed: 23876403]
24. Hamano M, Kuzuya M, Fujii R, Ogura H, Yamada M. Epidemiology of acute gastroenteritis outbreaks caused by Noroviruses in Okayama, Japan. J Med Virol. 2005;77(2):282–289 10.1002/jmv.20455 [PubMed: 16121370]
25. Bernard H, Höhne M, Niendorf S, Altmann D, Stark K. Epidemiology of norovirus gastroenteritis in Germany 2001-2009: eight seasons of routine surveillance. Epidemiol Infect. 2014;142(1) :63–74 10.1017/s0950268813000435 [PubMed: 23517686]
26. Pickering LK, Evans DG, DuPont HL, Vollet JJ III, Evans DJ Jr. Diarrhea caused by Shigella, rotavirus, and Giardia in day-care centers: prospective study. J Pediatr. 1981;99(1):51–56 10.1016/s0022-3476(81)80956-0 [PubMed: 6265616]
27. Genobile D, Gaston J, Tallis GF, et al. An outbreak of shigellosis in a child care centre. Commun Dis Intell Q Rep. 2004;28(2):225–229 [PubMed: 15460959]
28. Lin FH, Chou YC, Chen BC, et al. An increased risk of school-aged children with viral infection among diarrhea clusters in Taiwan during 2011–2019. Children (Basel). 2021;8(9):807 10.3390/children8090807 [PubMed: 34572239]
29. Gallimore CI, Barreiros MA, Brown DW, Nascimento JP, Leite JP. Noroviruses associated with acute gastroenteritis in a children's day care facility in Rio de Janeiro, Brazil. Braz J Med Biol Res. 2004;37(3):321–326 10.1590/s0100-879x2004000300005 [PubMed: 15060697]
30. Payne DC, Vinjé J, Szilagyi PG, et al. Norovirus and medically attended gastroenteritis in U.S. children. N Engl J Med. 2013;368(12):1121–1130 10.1056/NEJMsa1206589 [PubMed: 23514289]
31. Pindyck T, Tate JE, Parashar UD. A decade of experience with rotavirus vaccination in the United States - vaccine uptake, effectiveness, and impact. Expert Rev Vaccines. 2018;17(7):593–606 10.1080/14760584.2018.1489724 [PubMed: 29909693]
32. Hill HA, Yankey D, Elam-Evans LD, Singleton JA, Pingali SC, Santibanez TA. Vaccination coverage by age 24 months among children born in 2016 and 2017 - National Immunization Survey-Child, United States, 2017-2019. MMWR Morb Mortal Wkly Rep. 2020;69(42):1505–1511 10.15585/mmwr.mm6942a1 [PubMed: 33090985]
33. Lyman WH, Walsh JF, Kotch JB, Weber DJ, Gunn E, Vinjé J. Prospective study of etiologic agents of acute gastroenteritis outbreaks in child care centers. J Pediatr. 2009;154(2):253–257 10.1016/j.jpeds.2008.07.057 [PubMed: 18783794]
34. Lee MB, Greig JD. A review of enteric outbreaks in child care centers: effective infection control recommendations. J Environ Health. 2008;71(3):24–32, 46
35. Hebbelstrup Jensen B, Jokelainen P, Nielsen ACY et al. Children attending day care centers are a year-round reservoir of gastrointestinal viruses. Sci Rep. 2019;9(1):3286 10.1038/s41598-019-40077-9 [PubMed: 30824842]
36. Yan Y, Li Y, Shi W, et al. An outbreak of gastroenteritis associated with a novel GII.8 sapovirus variant-transmitted by vomit in Shenzhen, China, 2019. BMC Infect Dis. 2020;20(1):911 10.1186/s12879-020-05643-x [PubMed: 33261582]
37. Kim S, Kim YW, Ryu S, Kim JW. Norovirus outbreak in a kindergarten: human to human transmission among children. Infect Chemother. 2019;51(2):171–176 10.3947/ic.2019.51.2.171 [PubMed: 31270996]
38. Subahir MN, Jeffree MS, Hassan MR, et al. Norovirus outbreak among students of a boarding school in Kluang, Johor, Malaysia. J Infect Dev Ctries. 2019;13(4):274–277 10.3855/jidc.11199 [PubMed: 32045370]
39. Belongia EA, Osterholm MT, Soler JT, Ammend DA, Braun JE, MacDonald KL. Transmission of Escherichia coli O157:H7 infection in Minnesota child day-care facilities. JAMA. 1993;269(7):883–888 [PubMed: 8426447]

40. Li Y, Fan X, Yu G, Wei P, Wang Y, Guo H. An acute gastroenteritis outbreak associated with breakfast contaminated with norovirus by asymptotic food handler at a kindergarten in Shenzhen, China. BMC Infect Dis. 2021;21(1):54 10.1186/s12879-021-05762-z [PubMed: 33435906]
41. Lim MA, Kim JY, Acharya D, et al. A diarrhoeagenic *Enteropathogenic Escherichia coli* (*EPEC*) infection outbreak that occurred among elementary school children in Gyeongsangbuk-Do province of South Korea was associated with consumption of water-contaminated food items. Int J Environ Res Public Health. 2020;17(9):3149 10.3390/ijerph17093149 [PubMed: 32366011]
42. Mylius M, Dreesman J, Pulz M, et al. Shiga toxin-producing Escherichia coli O103:H2 outbreak in Germany after school trip to Austria due to raw cow milk, 2017 - The important role of international collaboration for outbreak investigations. Int J Med Microbiol. 2018;308(5):539–544 10.1016/j.ijmm.2018.05.005 [PubMed: 29884330]
43. Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States–major pathogens. Emerg Infect Dis. 2011;17(1):7–15 10.3201/eid1701.p11101 [PubMed: 21192848]
44. Capece G, Gignac E. Norovirus. In: StatPearls. Treasure Island, FL: StatPearls Publishing; August 11, 2021
45. Lively JY, Johnson SD, Wikswo M, Gu W, Leon J, Hall AJ. Clinical and epidemiologic profiles for identifying norovirus in acute gastroenteritis outbreak investigations. Open Forum Infect Dis. 2018;5(4):ofy049 10.1093/ofid/ofy049 [PubMed: 30568985]
46. Freedman SB, Xie J, Lee BE, et al. Microbial etiologies and clinical characteristics of children seeking emergency department care due to vomiting in the absence of diarrhea. Clin Infect Dis. 2021;73(8):1414–1423 10.1093/cid/ciab451 [PubMed: 33993272]
47. Carlton EJ, Woster AP, DeWitt P, Goldstein RS, Levy K. A systematic review and meta-analysis of ambient temperature and diarrhoeal diseases. Int J Epidemiol. 2016;45(1):117–130 10.1093/ije/dyv296 [PubMed: 26567313]
48. Liang M, Ding X, Wu Y, Sun Y. Temperature and risk of infectious diarrhea: a systematic review and meta-analysis. Environ Sci Pollut Res Int. 2021;28(48):68144–68154 10.1007/s11356-021-15395-z [PubMed: 34268683]
49. van Beeck AHE, Zomer TP, van Beeck EF, Richardus JH, Voeten HACM, Erasmus V. Children's hand hygiene behaviour and available facilities: an observational study in Dutch day care centres. Eur J Public Health. 2016;26(2):297–300 10.1093/eurpub/ckv228 [PubMed: 26659412]
50. Mattison CP, Dunn M, Wikswo ME, et al. Non-norovirus viral gastroenteritis outbreaks reported to the National Outbreak Reporting System, USA, 2009-2018. Emerg Infect Dis. 2021;27(2):560–564 10.3201/eid2702.203943 [PubMed: 33496216]
51. Conrad D, Dee K, Keenan A, Vivancos R. The role of household transmission in an outbreak of viral gastroenteritis in a primary school in Liverpool, England. Public Health. 2013;127(9):882–884 10.1016/j.puhe.2013.05.011 [PubMed: 23972357]
52. Venczel LV, Desai MM, Vertz PD, et al. The role of child care in a communitywide outbreak of hepatitis A. Pediatrics. 2001;108(5):E78 10.1542/peds.108.5.e78 [PubMed: 11694662]
53. Arvelo W, Hinkle CJ, Nguyen TA, et al. Transmission risk factors and treatment of pediatric shigellosis during a large daycare center-associated outbreak of multidrug resistant Shigella sonnei: implications for the management of shigellosis outbreaks among children. Pediatr Infect Dis J. 2009;28(11):976–980 10.1097/INF.0b013e3181a76eab [PubMed: 19738503]
54. Cates JE, Vinjé J, Parashar U, Hall AJ. Recent advances in human norovirus research and implications for candidate vaccines. Expert Rev Vaccines. 2020;19(6):539–548 10.1080/14760584.2020.1777860 [PubMed: 32500763]
55. Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand-washing promotion for preventing diarrhoea. Cochrane Database Syst Rev. 2021;12(1):CD004265 10.1002/14651858.CD004265.pub4 [PubMed: 33539552]
56. Centers for Disease Control and Prevention. Handwashing - clean hands save lives. Updated August 10, 2021. https://www.cdc.gov/handwashing/index.html. Accessed September 17, 2021
57. Tuladhar E, Hazeleger WC, Koopmans M, Zwietering MH, Duizer E, Beumer RR. Reducing viral contamination from finger pads: handwashing is more effective than alcohol-based hand disinfectants. J Hosp Infect. 2015;90(3):226–234 10.1016/j.jhin.2015.02.019 [PubMed: 25936671]

58. Enserink R, Mughini-Gras L, Duizer E, Kortbeek T, Van Pelt W Risk factors for gastroenteritis in child day care. Epidemiol Infect. 2015;143(13):2707–2720 10.1017/s0950268814003367 [PubMed: 25592679]

59. Isakbaeva ET, Bulens SN, Beard RS, et al. Norovirus and child care: challenges in outbreak control. Pediatr Infect Dis J. 2005;24(6):561–563 10.1097/01.inf.0000164764.58715.23 [PubMed: 15933572]

60. Butz AM, Fosarelli P, Dick J, Cusack T, Yolken R. Prevalence of rotavirus on high-risk fomites in day-care facilities. Pediatrics. 1993;92(2):202–205 [PubMed: 8393172]

61. Witta SD, Spencer HA. Using educational interventions to improve the handwashing habits of preschool children. Early Child Dev Care. 2004;174(5):461–471 10.1080/0300443032000153624

62. Younie S, Mitchell C, Bisson MJ, Crosby S, Kukona A, Laird K. Improving young children's handwashing behaviour and understanding of germs: The impact of A Germ's Journey educational resources in schools and public spaces. PLoS One. 2020;15(11):e0242134 10.1371/journal.pone.0242134 [PubMed: 33227004]

63. Lau CH, Springston EE, Sohn M-W, et al. Hand hygiene instruction decreases illness-related absenteeism in elementary schools: a prospective cohort study. BMC Pediatr. 2012;12(1):52 10.1186/1471-2431-12-52 [PubMed: 22587432]

64. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. Pediatrics. 2008;121(6):e1555–e1562 10.1542/peds.2007-2597 [PubMed: 18519460]

65. Kotch JB, Isbell P, Weber DJ, et al. Hand-washing and diapering equipment reduces disease among children in out-of-home child care centers. Pediatrics. 2007;120(1):e29–e36 10.1542/peds.2005-0760 [PubMed: 17606546]

WHAT'S KNOWN ON THIS SUBJECT:

Acute gastroenteritis illnesses spread rapidly in schools and childcare facilities, causing outbreaks and disrupting the learning process. Better understanding of etiologies and epidemiology of these outbreaks is needed to inform effective prevention and control measures.

WHAT THIS STUDY ADDS:

This study analyzes 4756 school and childcare acute gastroenteritis outbreaks in the United States reported through the National Outbreak Reporting System from 2009 to 2020. Most outbreaks were caused by norovirus or *Shigella* spp. and were spread via person-to-person transmission.

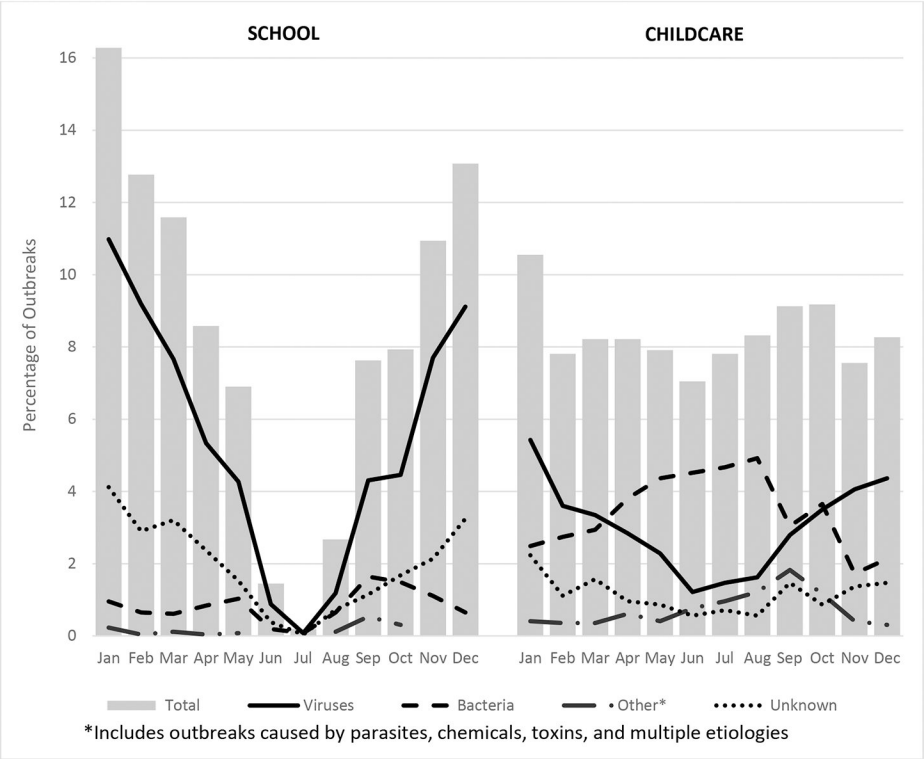

FIGURE 1.

Percentage of outbreaks per month, stratified by outbreak setting of school or childcare and reported etiology class, reported through the National Outbreak Reporting System, 2009–2019.

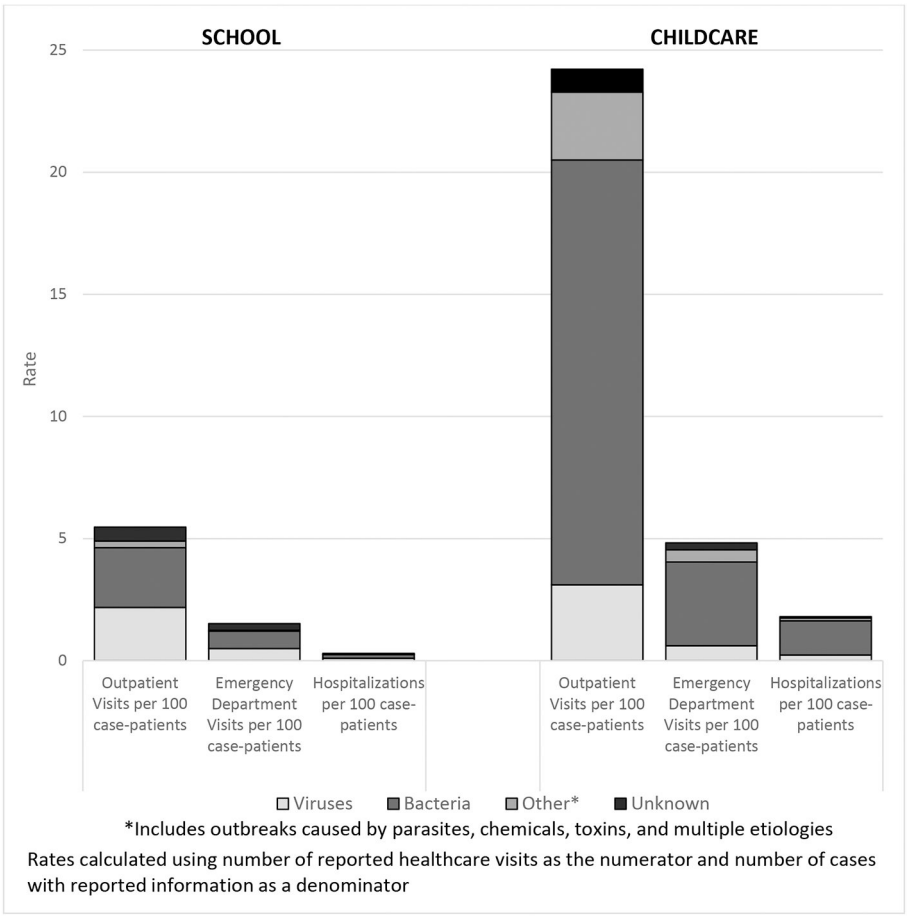

FIGURE 2.

Rate of health care utilization by outbreak setting and etiology class, among AGE outbreaks reported in schools and childcares through the National Outbreak Reporting System, 2009–2019. AGE, acute gastroenteritis.

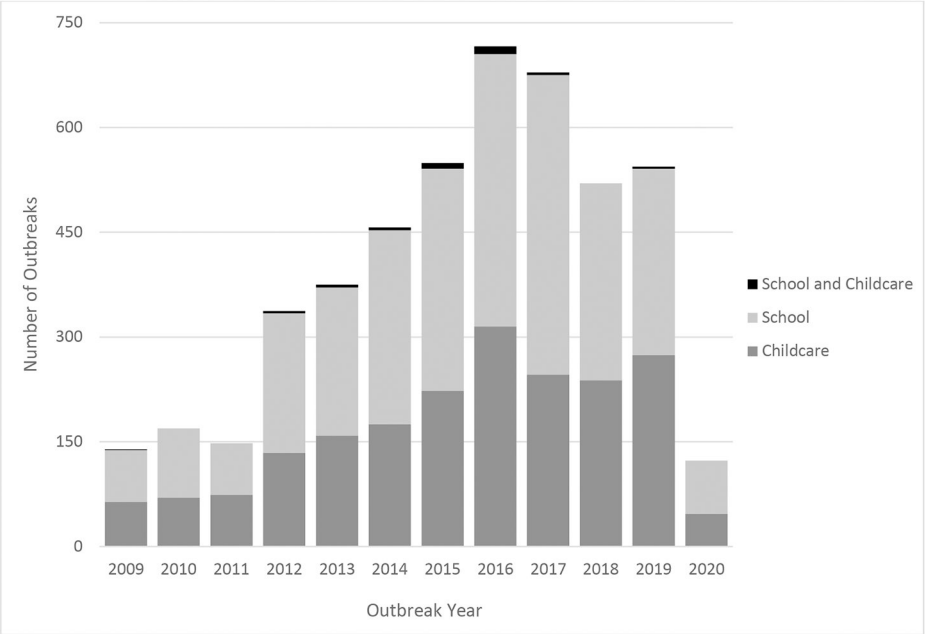

FIGURE 3.

Number of outbreaks in schools, childcares, and both settings reported through the National Outbreak Reporting System per year, 2009–2020.

TABLE 1

Outbreak Characteristics by Reported Etiology and Outbreak Setting of School or Childcare Facility, Reported Through the National Outbreak Reporting System, 2009–2019

	No. Outbreaks (%)		Total Cases (%)		Cases per Outbreak, Median (IQR)		Outbreak Duration in days, Median (IQR)	
Outbreak Etiology	**School *N* = 2623**	**Childcare *N* = 1972**	**School *N* = 132 557**	**Childcare *N* = 29 318**	**School 29 (13–63)**	**Childcare 10 (5–20)**	**School 9 (4–18)**	**Childcare 15 (8–26)**
Norovirus	1689 (64.4)	686 (34.8)	95 800 (72.3)	13 662 (46.6)	33 (15–71)	16 (10–25)	9 (4–17)	12 (7–20)
Shigella	202 (7.7)	537 (27.2)	2638 (2.0)	5962 (20.3)	6 (3–14)	7 (4–13)	25 (13–37)	21 (12–32)
Escherichia	9 (0.3)	129 (6.5)	273 (0.2)	884 (3.0)	14 (5–29)	5 (3–8)	10 (7–14)	16 (8–28)
Salmonella	19 (0.7)	117 (5.9)	312 (0.2)	655 (2.2)	11 (5–19)	4 (2–6)	16 (6–31)	17 (8–33)
Cryptosporidium	8 (0.3)	81 (4.1)	95 (0.1)	722 (2.5)	9 (6–12)	4 (3–8)	20 (13–29)	21 (13–32)
Other bacteria[a]	29 (1.1)	25 (1.3)	923 (0.7)	382 (1.3)	20 (9–47)	4 (2–12)	1 (1–3)	11 (4–18)
Other virus[b]	20 (0.8)	34 (1.7)	1008 (0.8)	505 (1.7)	35 (16–81)	12 (9–22)	15 (7–21)	15 (10–23)
Other parasite[c]		22 (1.1)		149 (0.5)		4 (3–8)		12 (5–38)
Chemical/toxin[d]	6 (0.2)		69 (0.1)		6 (5–6)		1 (1–1)	
Multiple[e]	26 (1.0)	70 (3.5)	2184 (1.6)	1178 (4.0)	57 (30–120)	13 (7–26)	29 (22–45)	19 (11–34)
Unknown	615 (23.4)	271 (13.7)	29 255 (22.1)	5219 (17.8)	31 (14–59)	13 (7–25)	8 (3–13)	11 (6–21)

[a] Other bacteria outbreaks include *Campylobacter* (*n* = 27), *Staphylococcus* (*n* = 11), *Clostridium* (*n* = 7), *Clostridioides* (*n* = 5), and *Bacillus* (*n* = 3) and other bacterium (*n* = 1).

[b] Other virus outbreaks include rotavirus (*n* = 30), sapovirus (*n* = 19), astrovirus (*n* = 4), and adenovirus (*n* = 1).

[c] Other parasite outbreaks include *Giardia* (*n* = 21) and *Cyclospora* (*n* = 1).

[d] Chemical/toxin outbreaks include scombroid toxin (*n* = 1), whitefish allergy (*n* = 1), copper (*n* = 1), and other chemical/toxin (*n* = 3).

[e] Multiple etiology outbreaks include outbreaks where more than 1 outbreak genus was reported. Most commonly reported genera were norovirus (*n* = 66), sapovirus (*n* = 33), *Escherichia* (*n* = 27), *Shigella* (*n* = 18), and rotavirus (*n* = 13).

TABLE 2

Number and Percentage of Outbreaks With Reported Mode of Transmission by Outbreak Setting of School or Childcare Facility, Reported Through the National Outbreak Reporting System, 2009–2019

Mode of Transmission	School (%) *N* = 2623	Childcare (%) *N* = 1972	Both School and Childcare (%) *N* = 38	Total (%) *N* = 4633
Person-to-person	2209 (84.2)	1733 (87.9)	29 (76.3)	3971 (85.7)
Unknown	296 (11.3)	202 (10.2)	6 (15.8)	504 (10.9)
Food	98 (3.7)	22 (1.1)	3 (7.9)	123 (2.7)
Environmental	7 (0.3)	7 (0.4)	0	14 (0.3)
Animal contact	6 (0.2)	5 (0.3)	0	11 (0.2)
Water	7 (0.3)	3 (0.2)	0	10 (0.2)