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Norovirus Outbreaks in Long-term Care Facilities in the United States, 2009–2018: A Decade of Surveillance

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Abstract

Background.—In the United States, norovirus is the leading cause of healthcare-associated gastroenteritis outbreaks. To inform prevention efforts, we describe the epidemiology of norovirus outbreaks in long-term care facilities (LTCFs).

Methods.—The Centers for Disease Control and Prevention (CDC) collect epidemiologic and laboratory data on norovirus outbreaks from US health departments through the National Outbreak Reporting System (NORS) and CaliciNet. Reports from both systems were merged, and norovirus outbreaks in nursing homes, assisted living, and other LTCFs occurring in 2009–2018 were analyzed. Data from the Centers for Medicare and Medicaid Services and the National Center for Health Statistics were used to estimate state LTCF counts.

Results.—During 2009–2018, 50 states, Washington D.C., and Puerto Rico reported 13 092 norovirus outbreaks and 416 284 outbreak-associated cases in LTCFs. Participation in NORS and CaliciNet increased from 2009 to 2014 and median reporting of LTCF norovirus outbreaks stabilized at 4.1 outbreaks per 100 LTCFs (interquartile range [IQR]: 1.0–7.1) annually since 2014. Most outbreaks were spread via person-to-person transmission (90.4%), and 75% occurred during December–March. Genogroup was reported for 7292 outbreaks with 862 (11.8%) positive for GI and 6370 (87.3%) for GII. Among 4425 GII outbreaks with typing data, 3618 (81.8%) were GII.4. LTCF residents had higher attack rates than staff (median 29.0% vs 10.9%; $P < .001$). For every 1000 cases, there were 21.6 hospitalizations and 2.3 deaths.

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Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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Conclusions.—LTCFs have a high burden of norovirus outbreaks. Most LTCF norovirus outbreaks occurred during winter months and were spread person-to-person. Outbreak surveillance can inform development of interventions for this vulnerable population, such as vaccines targeting GII.4 norovirus strains.

Keywords

norovirus; long-term care; outbreaks; surveillance

Noroviruses are the most prevalent cause of acute gastroenteritis (AGE) globally [1], and the leading cause of healthcare-associated AGE outbreaks in the United States [2]. These diverse RNA viruses are classified by capsid types into genogroups and genotypes, as well as by polymerase types into P-groups [3]. GI and GII noroviruses are the genogroups included in routine testing and most often identified in humans. Although noroviruses typically cause uncomplicated, self-limiting disease [4], norovirus gastroenteritis is estimated to cause around 470 000 emergency room visits, 110 000 hospitalizations, and 900 deaths in the United States each year [5], with adults aged 65 years and older at highest risk for severe outcomes [4, 6]. Long-term care facilities (LTCFs), which serve over 2 million Americans annually [7], are the most common setting of norovirus outbreaks [2, 8]. Noroviruses are primarily spread via the fecal-oral route and are introduced to LTCFs by an infected person through direct contact or environmental contamination or via contaminated foods [9]. The virus' low infectious dose [10], high environmental stability, prolonged and profuse shedding, and potential for asymptomatic infection make norovirus difficult to control [4]. Norovirus outbreaks are an important health risk for LTCFs, as advanced age and underlying health conditions of residents may lead to an increased risk of hospitalization and death [2, 11–14].

Two national systems for the surveillance of gastroenteric outbreaks were established by the US Centers for Disease Control and Prevention (CDC) in 2009. Outbreaks of foodborne, waterborne, and enteric diseases, including norovirus, are investigated by state, local, and territorial health departments and voluntarily reported to CDC using the web-based National Outbreak Reporting System (NORS). CDC monitors circulating and emerging norovirus strains by collecting typing data on laboratory-confirmed norovirus outbreaks, voluntarily uploaded by state and local public health laboratories through CaliciNet. A single norovirus outbreak may be reported to NORS, CaliciNet, or both systems, depending on laboratory confirmation and level of state participation in either surveillance system.

This analysis describes the epidemiology, burden, and outcomes of norovirus outbreaks in LTCFs using 10 years of data from NORS and CaliciNet.

METHODS

Norovirus outbreaks in LTCFs reported to NORS or CaliciNet that occurred in the United States with initial illness onset between 1 January 2009 and 31 December 2018 were included. Data on outbreak characteristics (eg, setting and etiology) and aggregate patient characteristics (eg, demographics and outcomes) are collected in NORS using standardized forms. An outbreak was defined as ≥2 cases of similar illness associated with a common

exposure. Outbreak etiologies reported in NORS may be suspected based on clinical or epidemiological characteristics or confirmed by laboratory testing. Norovirus outbreaks are reported to CaliciNet when norovirus-positive specimens from ≥2 cases are sequenced by a public health laboratory; reports also include limited epidemiologic data (outbreak size, setting, and transmission mode). Outbreaks are considered confirmed if any norovirus is detected in specimens from ≥2 cases; they are attributed to a norovirus genotype when there is agreement across specimens from the same outbreak. Mixed etiology outbreaks (ie, norovirus outbreaks with additional etiologies listed in NORS) were excluded from this analysis (n = 50).

As defined in NORS and CaliciNet, both long-term medical care facilities (nursing homes) and residential facilities that provide personal, nonmedical care (assisted living facilities) are considered LTCFs. Acute-care facilities, rehabilitation centers, and senior living complexes without care services are not considered LTCFs.

Data were downloaded from NORS on 4 November 2019 and from CaliciNet on 4 February 2020. Outbreaks from NORS and CaliciNet were matched using unique identifiers and verified using date of first illness (±30 days) and reporting site, then deduplicated. Because reporting to NORS and CaliciNet differs by state, the final data set included outbreaks reported to both systems, as well as those reported to NORS only or CaliciNet only. If an outbreak was reported to both systems, NORS data were used for epidemiological information, including outbreak setting, size and duration, mode of transmission, attack rates, age and sex distributions, and case outcomes, and data from CaliciNet were used for genotyping information. As outbreaks reported only to CaliciNet do not include case information, inclusion of these outbreaks was limited to genotype, mode of transmission, case count, seasonality, and overall burden analyses. Data on polymerase type were not captured until 2016; therefore, the inclusion of typing data in this analysis is limited to capsid typing (genotype).

Assessment of Outbreak Reporting

To estimate annual reporting rates for LTCF norovirus outbreaks by state, we used the average number of reports (limited to the years 2014–2018 after participation in NORS and CaliciNet stabilized) for each state and divided it by the estimated number of LTCFs in that state. The number of LTCFs was estimated using publicly available data (to match the surveillance definition): counts of licensed nursing homes were obtained through Centers for Medicare and Medicaid Services (CMS) from 2018 [15] and the number of assisted living facilities from the 2014 National Study of Long-Term Care Providers, administered by the National Center of Heath Statistics [16], were added to the CMS totals for each state. To assess the statistical significance of changes over time, the Cochran-Armitage test of trend [17] was used for the proportion of outbreaks with laboratory confirmation, and the Jonckheere-Terpstra test of trend [18] for outbreak size and duration.

Case Characteristics

Primary cases, defined as those in the initial cluster of illness, were included in this analysis (eg, in an LTCF outbreak primarily spread person-to-person, cases that occurred in the LTCF

among both residents and staff were included as primary cases, and known community spread to household members and visitors was excluded). Aggregate case information reported to NORS includes the number or percentage of cases with a given characteristic or outcome, and the number for whom that information was available to investigators. Proportions were calculated using the number of cases with information available as the denominator.

Outbreak Characteristics

Outbreak size was assessed using the total number of suspected and confirmed cases. Outbreak duration was calculated using the symptom onset dates of the first and last known cases, when available. Attack rates (AR) in NORS are calculated using the number of cases among staff or residents divided by the number of LTCF staff or residents with likely exposure. As AR is not always reported for staff, only outbreaks with non-missing ARs for both staff and residents were included in AR calculations. ARs among LTCF residents and staff were compared using a paired sample *t* test. The primary mode of transmission is based on the earliest cluster of illness, regardless of additional transmission routes that may occur during an outbreak's duration. The mode of transmission is considered person-to-person if there is no implicated food, water, or animal source, and if the initial illnesses were associated with direct contact with an infected person or their bodily fluids. Outbreaks with potential environmental exposure where both the infected and exposed individuals are simultaneously present are also categorized as person-to-person.

RESULTS

During 2009–2018, 52 sites (50 states, the District of Columbia, and Puerto Rico), reported 21 498 norovirus outbreaks to CDC (13 011 to NORS only, 3681 to CaliciNet only, and 4806 to both systems). Of these, 13 092 (60.9%) occurred in LTCFs, involving 416 284 outbreak-associated cases. In NORS, norovirus accounted for 95% of outbreaks with a single, confirmed etiology and 98% of those with a suspected etiology.

When available to investigators, information on age, sex, and case outcomes is reported to NORS in aggregate (Table 1). The majority of cases were female (75.6%) and aged 75 years or older (65%). There were 6641 hospitalizations and 729 deaths attributed to outbreak-associated norovirus AGE, corresponding to a hospitalization rate of 21.6 per 1000 cases and a death rate of 2.3 per 1000 cases.

Outbreak Reporting Trends

The number of sites reporting to NORS and CaliciNet and the number of outbreaks reported per site increased during the first several years of surveillance, corresponding to an increase in the total number of norovirus outbreaks reported in LTCFs from 468 in 2009 to 1677 in 2014 (Supplementary Table 1). The number of reports received remained high after 2014 with a maximum of 1860 LTCF outbreaks reported in 2018. During this more consistent reporting period from 2014 to 2018, sites reported a median of 4.1 norovirus outbreaks per 100 LTCFs per year. The level of state participation in norovirus surveillance varied, with

the average annual outbreak reporting rates ranging from <0.1 outbreaks per 100 facilities per year (3 sites) to 34.7 outbreaks/100 facilities during the same 5-year period.

Median outbreak size declined steadily from 34 cases in 2009 to 20 in 2018, and the median duration of outbreaks shortened from 12 days in 2009 to 8 days in 2018 (Supplementary Table 1). Tests for trend showed both decreases were statistically significant ($P < .001$). Stratification of outbreaks by case count and duration showed that these decreases were driven by increased reporting of small to medium sized outbreaks throughout the study period, whereas reporting of the largest outbreaks remained steady at a low level since 2009 (Supplementary Figure 1).

Outbreak Characteristics

Person-to-person spread was identified as the primary mode of transmission in 11 836 (90.4%) outbreaks (Table 2). Foodborne and environmental transmission were reported in <1% of LTCF outbreaks. The remaining 9% of outbreaks had insufficient evidence for investigators to determine the mode of transmission. Outbreak occurrence showed a pronounced seasonal distribution, with 91% of outbreaks occurring between October and April and 75% between December and March (Figure 1). The median attack rate for facility residents was 29.0%, significantly higher than the median attack rate of 10.9% for facility staff (n = 5793, $P < .001$) (Table 2).

Laboratory Data

Norovirus was confirmed in ≥2 case specimens in 8075 (62%) outbreaks. Among these, genogroup was reported for 7297 outbreaks: 862 (11.8%) were GI, 6370 (87.3%) were GII, 8 (0.1%) were other genogroups, and 57 (0.8%) identified 2 or more genogroups. Typing data were available for 5027 norovirus GI and GII LTCF outbreaks reported to CaliciNet (Figure 2). Among 602 GI outbreaks reporting genotype, the top strain was GI.3 (n = 281), followed by GI.6 (n = 118). Among 4425 GII outbreaks reporting genotype, 3618 (81.8%) were GII.4, among which GII.4 Sydney (n = 3011) and GII.4 New Orleans (n = 496) were the most common variants. GII.4 outbreaks had a median case count of 31 (non-GII.4 median case count = 27) and 2.5% of GII.4 outbreak cases were hospitalized (1.4% in non-GII.4 outbreaks).

Of note, both the proportion of norovirus outbreaks with laboratory confirmation and the absolute number of laboratory-confirmed outbreaks have decreased since 2014 ($P < .001$) (Supplementary Table 1). Laboratory confirmed norovirus outbreaks tended to have longer duration (median 11 days vs 8 days) and more cases (median 27 vs 21) compared to outbreaks without laboratory confirmation.

DISCUSSION

Nearly 60% of reported norovirus outbreaks in the United States during the study period occurred in LTCFs. Overall, 13 092 LTCF norovirus outbreaks and 416 284 associated cases were reported to NORS or CaliciNet from 2009 to 2018. In NORS, norovirus accounted for 95% of AGE in LTCFs with a confirmed etiology, and 98% of those with a suspected etiology. State participation in NORS and CaliciNet increased during the

first 5 years of surveillance, with improved reporting of smaller outbreaks and steady reporting of large outbreaks observed across the 10-year period. The total number of LTCF norovirus outbreaks reported per year stabilized after 2014 at a median across all sites of 4.1 outbreaks per 100 LTCFs; however, laboratory confirmation of norovirus decreased during the same time. Most outbreaks were spread via person-to-person transmission (90.4%) and occurred during the winter months. Cases were mostly elderly (65% of cases were aged ≥75), and 75% were female. Nearly 87% of LTCF outbreaks with genotype data were GII norovirus, and the predominant strain of norovirus identified was G.II4 Sydney. Some cases experienced severe outcomes from outbreak-associated norovirus, with a hospitalization rate of 21.6 per 1000 cases and a death rate of 2.1 per 1000 cases.

The predominance of norovirus among AGE outbreaks in LTCFs is seen globally. A national surveillance platform in Norway reported suspected or confirmed norovirus in 96% of hospital and LTCF outbreaks [19]. Surveillance data from northeastern England also showed that when limited to outbreaks with laboratory confirmed etiology, norovirus caused the majority (64%) of enteric LTCF outbreaks; however, another 13% were sapovirus and 11% were rotavirus [20]. Because outbreaks caused by these other pathogens present with similar clinical and epidemiologic characteristics to norovirus [21], it is possible that a portion of the more than 5000 LTCF outbreaks without laboratory confirmation in NORS may be misclassified as norovirus, underscoring the need for collection and testing of outbreak-associated specimens when possible.

The median reporting rate of 4 norovirus outbreaks per 100 LTCFs/year was low compared to other studies conducted in the United States and Europe [22–24]. Reporting to NORS and CaliciNet is voluntary and may not capture all outbreaks reported to health departments. We observed high variability in reporting rates between states, which is likely due to differences in state-mandated reporting criteria for healthcare-associated outbreaks and difficulties reporting in some jurisdictions due to understaffing at health departments or LTCFs. Although the merging of data from NORS and CaliciNet improves the comprehensiveness of our dataset, our incidence estimates likely represent the lower bound of the true burden.

The observed decrease in median case counts and outbreak duration from 2009 to 2018, as well as the overall increase in outbreak reports may also be explained by trends in reporting. Larger and more sustained outbreaks may have been prioritized for reporting when the systems were new, and as reporting improved to include smaller outbreaks, the median outbreak size and duration decreased accordingly. This improved reporting of smaller outbreaks may also contribute to the observed decrease in the proportion of outbreaks with laboratory confirmation, as large outbreaks were more likely to have laboratory confirmation.

Our finding of a relatively high burden of morbidity and mortality attributed to norovirus outbreaks in LTCFs aligns with previous research [5, 11, 13, 25, 26]. A recent analysis of US administrative data estimated that adults aged ≥65 years accounted for 86% of norovirus-associated deaths and 43% of norovirus-associated hospitalizations [5]. LTCF residents are more susceptible to severe norovirus infection compared to the general population [25]. At an individual level, severe outcomes may be linked to underlying health conditions [12,

13, 27], including immunosuppression [14], and preexisting dehydration, which is common among LTCF residents [28, 29]. Additionally, aspiration pneumonia has been cited as a direct cause of norovirus deaths [14], suggesting reduced mobility may be a key factor in norovirus complications in healthcare settings.

Most norovirus cases occurred among women and people aged ≥75 years, which is consistent with the overall distribution of sex and age among LTCF residents and staff [15, 30]. Norovirus in the United States has previously been shown to have a strong winter peak [6], with similar seasonal trends observed in healthcare settings in Europe [19, 31]. Person-to-person spread has been previously described as the predominant mode of transmission of norovirus in NORS [32] and elsewhere [22, 23].

Most outbreaks with available typing data were classified as GII.4 strains, which is consistent with previous data in healthcare facilities [33]. GII.4 strains have been associated with more severe clinical outcomes [33, 34] and longer shedding duration [27], exacerbating challenges in outbreak control. This is consistent with the larger outbreak size and increased hospitalizations among GII.4 outbreaks observed in our data. Vaccine protection specific to the predominant GII.4 norovirus strains is therefore an important consideration in ongoing vaccine development efforts [35].

Our analysis has several limitations inherent to the surveillance systems. First, because facilities are not identified and case data are reported in aggregate in NORS and CaliciNet, we can neither assess LTCF characteristics that influence outbreak risk nor individual risk factors for case outcomes. We were also unable to compare the burden of norovirus across states due to differences in state participation in NORS and CaliciNet. Of note, data quality for all variables is reliant on the cooperation of LTCFs and local health departments; even states that do routinely report to NORS and CaliciNet face challenges in obtaining epidemiologic data and specimens for testing from LTCFs and may consequentially report incomplete data. If outbreak investigators focus on LTCF residents, it is possible that the burden of norovirus outbreaks on LTCF staff is underrepresented. Because secondary cases are not consistently reported in NORS, we could not assess the potential impact of community spread. To describe genotypic variation, we focused on capsid genotype as it was consistently available for the 10-year period. Future analyses are needed to further describe the patterns of specific genetic variants of norovirus in LTCFs and their potential impact. NORS and CaliciNet capture complementary information but are not utilized consistently across jurisdictions; recent linkage of the 2 web-based platforms may pave the way to in-depth assessment of effects of genotype on epidemiologic outbreak characteristics. Finally, NORS has not historically distinguished between different levels of LTCF care, such as skilled nursing homes and assisted living facilities; however, updates to NORS are in development to provide more granular information on LTCF type for future analysis.

Our analysis contributes 10 years of outbreak data to the body of knowledge on norovirus in LTCFs, and the merging of data from 2 national systems allows for a more comprehensive review compared to previous studies. We show that although reporting of LTCF norovirus outbreaks has improved over time, challenges in prevention and testing of these outbreaks remain. Continued resource support for the detection, investigation, and reporting of

norovirus outbreaks is needed to understand the true burden of norovirus in LTCFs. Our data confirm that norovirus outbreaks contribute substantially to morbidity and mortality in LTCFs. Therefore, norovirus remains a prime target for interventions in LTCFs, including standard infection control procedures, and LTCF residents and staff are an important risk group for targeted interventions such as vaccines.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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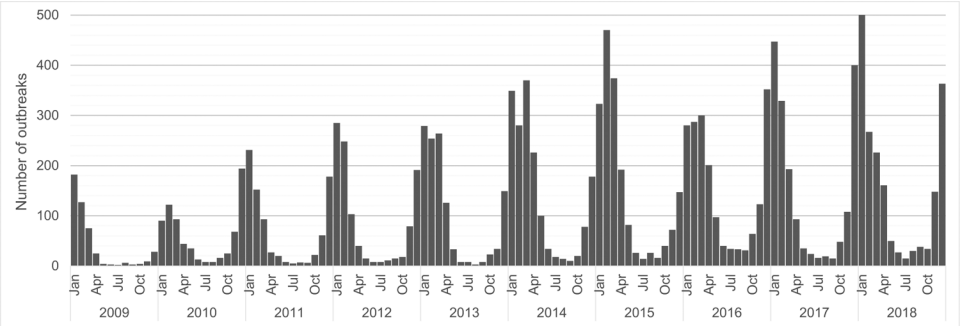

Figure 1.

Seasonal distribution of norovirus outbreaks in long-term care facilities in the United States reported to NORS and CaliciNet from 2009 to 2018. Abbreviation: NORS, National Outbreak Reporting System.

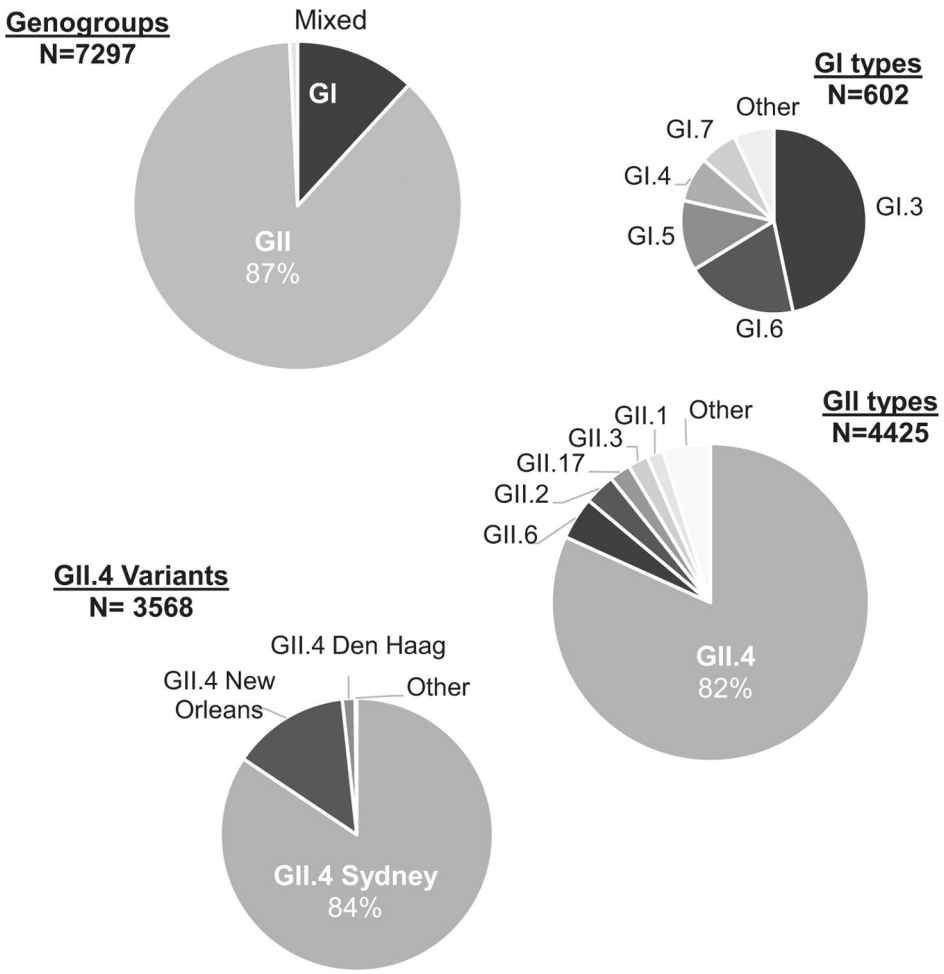

Figure 2.

Norovirus genogroups and capsid types identified in long-term care facility acute gastroenteritis outbreaks reported to NORS and CaliciNet from 2009 to 2018. GI and GII norovirus genogroups are categorized into genotypes and GII.4 variants are broken out. Abbreviation: NORS, National Outbreak Reporting System.

Table 1.

Case Characteristics and Outcomes of Norovirus Outbreaks in Long-term Care Facilities Reported to National Outbreak Reporting System (NORS) or CaliciNet From 2009 to 2018

Case Characteristic/Outcome[a]	Cases With Information	n (%)
Age in years		
<50	142 429	22 095 (15.5)
50–74		27 843 (19.6)
≥75+		92 490 (64.9)
Sex		
Male	209 410	158 317 (75.6)
Female		51 092 (24.4)
Hospitalizations	306 722	6641 (2.16)
Deaths	321 300	729 (0.23)

[a]Data on case age groups were included in 5304 (40.5%) outbreak reports, sex in 6262 (47.8%), hospitalizations in 9196 (70.2%), and deaths in 9501 (72.6%) reports.

Table 2.

Characteristics of Norovirus Outbreaks in Long-term Care Facilities Reported to National Outbreak Reporting System (NORS) or CaliciNet From 2009 to 2018

Outbreak Characteristic[a]	
Attack rate[b], median (IQR)	
Staff	10.9 (4.0–22.0)
Residents	29.0 (16.4–44.6)
Overall	20.2 (11.0–32.0)
Duration in days[c], median (IQR)	10 (6–16)
Case count, median (IQR)	25 (13–41)
Mode of transmission, n (%)	
Person-to-person	11 836 (90.4)
Food	77 (0.6)
Environmental	8 (0.1)
Unknown	1171 (8.9)

Abbreviations: IQR, interquartile range; LTCF, long-term care facility.

[a]Data on attack rate were included in 5793 (44.3%) reports, outbreak duration in 9544 (72.9%) outbreak reports, and estimated case counts and mode of transmission were included in 13 092 (100%) reports.

[b]Attack rate was calculated as the number of cases (LTCF residents and/or staff) divided by the number of residents and/or staff exposed.

[c]Duration was calculated as the number of days from the symptom onset of the first case to the symptom onset of the last case identified in an outbreak.