**Introduction**

**Health and Economic Burdens of Foodborne Illness**

Frequently cited statistics indicate that the health and economic burden of foodborne disease is a serious public health problem, particularly for vulnerable populations such as children. The purpose of the descriptive retrospective study discussed in this article was to analyze data collected within the Electronic Foodborne Outbreak Reporting System (eFORS) in school settings in order to examine the magnitude of foodborne disease etiologies and to recommend strategies for prevention. Data on foodborne outbreaks \( N = 96 \) and illnesses \( N = 6,567 \) were extracted and analyzed from the Centers for Disease Control and Prevention’s (CDC’s) eFORS spanning the years 2000 to 2004.

**Norovirus in School Settings**

Few studies have been conducted in order to determine the burden of norovirus in school settings. Three Government Accountability Office (GAO) reports highlighted food safety as a growing concern in school settings (GAO, 2000; GAO, 2003; GAO, 2006). Daniels and co-authors (2002) examined outbreaks occurring in school settings from 1973 through 1997 and findings from that study indicate that 14 viral outbreaks were reported. Of those, Norwalk-like viruses accounted for five outbreaks, affecting a total of 804 persons and resulting in two hospitalizations. Findings from the Daniels and co-authors study indicated that bacterial pathogen outbreaks accounted for a greater proportion of outbreaks than those of viral etiology. *Salmonella* was identified in 36% of outbreak reports with a confirmed etiology.

The proportion of norovirus outbreaks of confirmed etiology nationwide increased from 1% in 1991 to 12% in 2000 (Widdowson, 2005). Development of more sensitive molecular diagnostic techniques over the last several years has allowed for a more accurate estimation of the burden of norovirus. School environments are increasingly becoming the most common settings for the occurrence of norovirus outbreaks, in large part because norovirus tends to thrive well in closed to semiclosed environments like schools (Lynch, Painter, Woodruff, & Braden, 2006). The purpose of our descriptive retrospective study was to analyze data collected within the Electronic Foodborne Outbreak Reporting System (eFORS) in school settings in order to examine the magnitude of foodborne disease etiologies, particularly norovirus, and to recommend strategies for prevention.

Norovirus (genus *Norovirus*, family *Caliciviridae*) is an important foodborne illness because it is a major cause of acute gastroenteritis in schoolchildren and the cause of significant absenteeism in the U.S. Norovirus outbreaks are very difficult to contain due to the fact that the pathogen is highly contagious. Norovirus is transmitted through food, water, and person-to-person contact and only a small infectious dose (less than 100 viral particles) is required to cause infection. Viral shedding can occur over a prolonged period of time even without clinical symptoms. The pathogen is extremely persistent in the environment and resistant to disinfection via agents. The incubation period

**Abstract**

Frequently cited statistics indicate that the burden of foodborne disease is a serious public health problem, particularly for vulnerable populations such as children. The purpose of the descriptive retrospective study discussed in this article was to analyze data collected within the Electronic Foodborne Outbreak Reporting System (eFORS) in school settings in order to examine the magnitude of foodborne disease etiologies and to recommend strategies for prevention. Data on foodborne outbreaks \( N = 96 \) and illnesses \( N = 6,567 \) were extracted and analyzed from the Centers for Disease Control and Prevention’s (CDC’s) eFORS spanning the years 2000 to 2004.

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for norovirus is 12–48 hours and the infection can last from 12 to 60 hours. Onset of symptoms is acute and generally includes abdominal cramps, vomiting, watery nonbloody diarrhea, and at times mild fever. Dehydration is common and in this context is a particular concern for children. Most foodborne norovirus outbreaks are the result of direct contamination of food with vomitus or feces or by an ill food handler, immediately following service and consumption (American Medical Association et al., 2004; Chin, 2000).

Methods

eFORS Surveillance Data Analyses

The surveillance data used to analyze foodborne illnesses and outbreaks occurring in schools settings were extracted from CDC’s eFORS (CDC, 2006a). The eFORS was designed as a means for state health departments to report foodborne disease outbreaks. This passive or voluntary reporting system is currently used by 50 states. It is important to note that local and state health departments have primary responsibility for investigating foodborne outbreaks but reporting them in eFORS is voluntary. Therefore, the quality of the data in eFORS will vary from state to state due to the voluntary nature and specific standards of reporting outbreaks. State health departments report intentional and unintentional foodborne disease outbreaks of bacterial, viral, parasitic, and toxic etiology. The eFORS contains important data on all reported confirmed and unconfirmed foodborne illness outbreaks including etiology, state, year and month, number of illnesses, food vehicle, suspect pathogen, and specific settings (e.g., schools, daycare centers, restaurants, churches, camps, etc.). The inherent value of eFORS is in the timely reporting of state foodborne illnesses and outbreaks and its capability to track foodborne disease by time, pathogen, location, the number of illnesses, and food vehicle.

A foodborne illness, by definition, is caused by harmful bacteria, viruses, parasites, or chemicals in food and beverages that enter the body through the gastrointestinal tract. Typical symptoms include vomiting, nausea, cramps, and diarrhea. A foodborne outbreak is defined as a cluster of two or more infections caused by the same agent (foodborne pathogen or toxin) and confirmed etiology determined by epidemiological evidence (laboratory confirmation) linked to the same food (CDC, 2006b).

Descriptive Statistics

Descriptive statistics were performed in order to characterize confirmed outbreaks and illnesses by etiologic agent, month (season), food vehicle, and state reports. Data were analyzed using SAS (Statistical Analysis System) (version 9.1, 2006) and Microsoft Office Excel 2003.

Analysis

Linear regression was performed using SAS to evaluate for trends in the number of confirmed bacterial and norovirus outbreaks and illnesses over time (2000–2004).

Results

Foodborne Disease Outbreaks of Unknown, Bacterial, Chemical, Parasitic, and Viral Etiology

When comparing the percentage of outbreaks occurring in school settings by etiology, outbreaks of unknown (unconfirmed) etiology consistently accounted for the highest percentage of outbreaks followed by confirmed viral, bacterial, chemical, and parasitic etiologies (Figure 1).

Trends for confirmed bacterial and viral outbreaks and illnesses over five years show interesting patterns. The number of foodborne outbreaks and illnesses attributed to bacterial etiology has steadily declined. Even though outbreaks attributed to norovirus have declined (Figure 2), the magnitude of outbreaks has increased as can be seen from the number of illnesses associated with norovirus outbreaks. The magnitude (number of illnesses) of norovirus outbreaks has shown a linear increase over time (Figure 3).

Foodborne Disease Outbreaks of Confirmed Etiology by Common Pathogens

When confirmed foodborne illness outbreaks were broken down by common pathogens such as Salmonella (all serotypes), Salmonella typhimurium, Shigella (all species), Staphylococcus aureus, Clostridium perfringens, Bacillus cereus, Campylobacter jejuni, E. coli O157:H7, norovirus, Vibrio (all species),
metal, and chemical, the percentage of noro-

virus outbreaks was highest (Figure 4).

The significance of norovirus outbreaks
and illnesses in school settings is evident
when compared to bacterial outbreaks and
illnesses. Of the 92 outbreaks and 6,407 ill-
nesses of confirmed etiology reported in
school settings, 57 outbreaks (62%) and
4,312 (67%) associated illnesses were attrib-
uted to viral (norovirus) etiology, while 35
(38%) outbreaks and 2,095 (33%) associated
illnesses were attributed to bacterial etiology.
The mean percentage of norovirus illnesses
was 65.12% while the mean percentage of
bacterial illnesses was 32.74% (Table 1).

Seasonal and Monthly Patterns of
Confirmed Norovirus Outbreaks
When comparing the magnitude of confirmed
norovirus outbreaks by the number of illnesses
by month of year in school settings, data indi-
cate that for most years, the number of illness-
es peak in the winter, followed by the spring
months. Other cited surveillance findings
(Lopman, Adak, Reacher, & Brown, 2003),
however, indicate that the general pattern for
norovirus in these settings is for illness to oc-
cur during the winter months. Illness caused
by norovirus is often referred to as the "win-
ter vomiting disease." The pattern observed in
school settings is different and represents the
persistent and sustained nature of norovirus in
schools or semi-closed environments.
Confirmed Norovirus Outbreaks by Known Versus Unknown Food Vehicle

When comparing the percentage of norovirus outbreaks of confirmed etiology by known compared to unknown food vehicle, the food vehicle is unknown in 56.1% of outbreaks, and the food vehicle is known in 43.9% of outbreaks. Foods are generally contaminated with norovirus via infected food handlers, which makes identifying food vehicles, particularly when multiple foods are involved, somewhat difficult (Schmid et al., 2007).

Food Vehicles Associated With Norovirus Outbreaks

Identified food vehicles associated with norovirus outbreaks in school settings spanned many food categories (multi-ingredient foods and salads, sandwiches, produce, dessert foods, eggs, poultry, dairy, meats) and caused outbreaks and illnesses across all years studied. Large-scale norovirus outbreaks involving both known and unknown food vehicles were evident in all years of data analyses. Norovirus outbreaks are typically associated with cold foods (salads, sandwiches), baked goods, and liquid foods (salad dressings, cake icing) where the virus can be easily mixed into the medium. Food vehicles associated with norovirus outbreaks, however, involved many different food categories (multi-ingredient foods and salads, sandwiches, produce, dessert foods, eggs, poultry, dairy, and meats). The two largest outbreaks of known food vehicles based on the eFORS data occurred in 2001, when 329 illnesses were associated with cheesecake, and in 2004, when 425 illnesses were associated with a salad bar.

Discussion

Analyses of eFORS data highlight some important findings. A higher percentage of outbreaks of unknown etiology occurred, which accounts for half or slightly greater than half of all outbreaks occurring in school settings. Outbreaks of viral and bacterial etiologies combined account for the remaining outbreaks of known etiology. Viral outbreaks remained stable in all years except in 2003, which saw a decline in the percentage of viral outbreaks. Outbreaks of viral and bacterial etiologies combined pose a great public health risk and viral etiologic illnesses constituted the most significant proportion of outbreaks in school settings. This increase coincided with the national increase in viral outbreaks.

Among all common pathogens (Salmonella [all serotypes], Salmonella typhimurium, Shigella [all species], Staphylococcus aureus, Clostridium...

**FIGURE 4**

*Percentage of Outbreaks in School Settings by Common Pathogens*

- **Pathogen**
  - Metal/Scombrotoxin
  - Vibrio spp.
  - Norovirus
  - E. coli O157:H7
  - B. cereus
  - C. jejuni
  - C. perfringens
  - S. aureus
  - Shigella spp.
  - S. typhi
  - Salmonella spp.

- **Percentage of Outbreaks**
  - 2000 Outbreaks of Confirmed Etiology
  - 2001 Outbreaks of Confirmed Etiology
  - 2002 Outbreaks of Confirmed Etiology
  - 2003 Outbreaks of Confirmed Etiology
  - 2004 Outbreaks of Confirmed Etiology
Norovirus is common in school settings and poses a significant public health problem. Outbreaks have a dramatic impact on school attendance and the health of the student and staff population. It is anticipated that outbreaks will increasingly be an issue and a challenge in school settings. Therefore, it is crucial to promote food safety education and prevention efforts as well as to promote proper sanitation to limit the spread of the virus. Norovirus is not only difficult to contain but also difficult to recognize by health professionals in school settings and not generally identified through routine clinical testing (CDC, 2005).

Federal, state, and local food safety educational campaigns, particularly at schools, must be launched throughout the year but especially during high-risk seasons for norovirus. A number of food safety educational resources are geared towards schools that highlight the steps that can be taken by food service staff to reduce the likelihood of a norovirus outbreak. Food handlers must be trained in safe food handling and taught that their own infections can contaminate foods. Resources include Serving It Safe, published by the National Food Service Management Institute (National Food Service Management Institute, 2004) or the materials produced by the Scrub Club, launched by NSF International (NSF International, The Partnership for Food Safety Education, 2007) are useful in increasing awareness of hand washing. During a norovirus outbreak, specific guidance should be posted instructing people in frequent hand washing.

Food handlers and health professionals (i.e., school nurses, aides) based in school settings must be trained on how to prevent norovirus and how to recognize norovirus outbreaks. Training for health professionals must include rapid implementation of control measures so that containment is both swift and effective. Training must focus on recognition of the symptoms associated with norovirus outbreaks and implementation of appropriate control measures as outlined by CDC (2003) such as promoting hand washing by school staff and students and disinfection of surfaces with the proper concentration of bleach solution. Since the onset of norovirus is acute, it is important to identify norovirus outbreaks promptly as to limit the spread of the outbreaks.

Given that more than half of norovirus outbreaks involve unknown food vehicles, detection methods must be developed that can be utilized in school settings to limit the spread of the outbreak and associated illnesses.

Efforts to reduce the impact of norovirus outbreaks on schools should also include an educational component aimed towards increasing hand washing by students, teachers, foodservice personnel, and others in the school community. Resources such as the “Wash your hands: Educating the School Community” kit published by the National Food Service Management Institute (National Food Service Management Institute, 2004) or the materials produced by the Scrub Club, launched by NSF International (NSF International, The Partnership for Food Safety Education, 2007) are useful in increasing awareness of hand washing. During a norovirus outbreak, specific guidance should be posted instructing people in frequent hand washing.

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GIS analysis would be a very useful tool to utilize in analyzing school foodborne disease
outbreaks by providing an additional layer of information via spatial analyses of norovirus strain types detected by clinical evaluation in addition to relying on state reports of outbreaks (Gallimore, 2004).

The increased reporting of outbreaks noted in 2004 may be a function of improved detection methods such as reverse transcription-polymerase chain reaction (RT-PCR) tests on stool samples (CDC, 2005) as well as improvements in state reports of foodborne disease and increased public awareness.

It is expected that as foodborne disease surveillance efforts and tools continually improve and acquire greater sensitivity, a positive impact will be noted in terms of the accuracy in reports on the number of reported outbreaks and illnesses and thus the burden of norovirus outbreaks in school settings.

Data Limitations

The eFORS is a passive surveillance system. As such, the data collected were voluntarily submitted by state health departments, vary from state to state, and probably underestimate the burden of norovirus outbreaks in school settings. Foodborne illness outbreak data submitted to eFORS undergo some degree of revision as more information is received about specific outbreaks. Therefore, the data analyzed in this study represent an estimate of actual data and burden of norovirus in school settings.

Acknowledgements: Thanks to reviewers Craig Hedberg, Jeff Bender, Robert Veninga, and James Hart at the University of Minnesota, School of Public Health, for their critique and comment.

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