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During 1994–1996, *Shigella sonnei* outbreaks occurred in 8 North American traditionally observant Jewish communities. These communities remain relatively separate from neighboring populations while maintaining close contact by travel with coreligionists in other cities. Epidemiologic investigations suggested community-to-community transmission via travel. Outbreak-related and control isolates of *S. sonnei* from each city were subtyped by pulsed-field gel electrophoresis (PFGE) to confirm an epidemiologic linkage between outbreaks. Forty-three (94%) of 46 outbreak-related isolates had closely related PFGE patterns, constituting a single subtype; 33 (94%) of 35 control isolates demonstrated unrelated PFGE patterns. Several patterns differing by ⩽3 bands were identified within the outbreak subtype; one of these accounted for 65% of outbreak isolates. Hence, a single subtype of *S. sonnei* caused an international outbreak involving 8 traditionally observant Jewish communities, but not neighboring populations, over a 2-year period, suggesting sustained propagation of the epidemic strain between communities.

Shigella sonnei is a major bacterial agent of diarrheal illness and a leading cause of bacillary dysentery in the United States [1]. In 1995, 14,811 laboratory-confirmed cases of *S. sonnei* infection were reported in this country [2], although laboratory-based surveillance detects only ~5% of cases [3]. Resistance to multiple antimicrobial agents emerged in the United States in the 1980s and is now commonplace among *S. sonnei* strains [4, 5].

Sustained person-to-person transmission accounts for most infections, which occur most commonly in children between the ages of 6 months and 10 years [1]. Community outbreaks in schools or day care centers can last for weeks or months and are propagated by the limited hygienic practices of young children [6]. Sudden common-source outbreaks of shigellosis are uncommon.

Outbreaks of shigellosis in geographically noncontiguous Jewish religious communities have also occurred, including a multistate outbreak encompassing communities in four states in 1987, with 1778 culture-confirmed cases [7]. However, definitive laboratory evidence that the outbreaks were related was not sought at that time.

Several molecular subtyping schemes for *S. sonnei* have been used in epidemiologic investigations. These include ribotyping [8], plasmid analysis [9], pulsed-field gel electrophoresis

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(PFGE) [9], and amplification by polymerase chain reaction [10]. The purpose of this study was to assess the utility of PFGE for subtyping *S. sonnei* and for determining whether a series of outbreaks of *S. sonnei* in traditionally religious Jewish communities in different cities during 1994–1995 were related. We subtyped *S. sonnei* isolates from these outbreaks, as well as temporally and geographically matched *S. sonnei* isolates from neighboring populations outside these communities, to determine if these outbreaks were related to other *Shigella* infections in each area.

Methods

Epidemiologic investigation. *Shigella* outbreaks were reported in several traditionally observant Jewish communities in North America during 1994–1995. This led us in November 1995 to survey local health departments in 12 North American cities with traditionally observant Jewish communities about outbreaks of *S. sonnei* within the preceding 12 months. In cities where an outbreak had occurred, 6 isolates of *S. sonnei* from outbreak patients within the religious community, temporally representative of the course of the outbreak, and 6 isolates from patients with *S. sonnei* infection in the same city who were not part of that community (control isolates) were requested from the city or state health department laboratory. Control isolates could not be obtained for New York City and St. Louis County, Missouri, because the outbreaks had occurred a year before the request. A case was defined as a culture-confirmed *S. sonnei* infection occurring in a person belonging to a traditionally observant community during a recognized community-wide shigellosis outbreak. Membership in such a community was determined by epidemiologic investigation carried out by local health departments and was typically based on attendance at a religious school or residence in a census tract largely inhabited by members of the traditionally observant community. A control was defined as a culture-confirmed *S. sonnei* infection in a person not belonging to the community and occurring 3–6 months before the community outbreak.

PFGE. Total genomic DNA was embedded in agarose plugs as previously described [11] and restricted with *Avr*II according to the manufacturer's instructions (New England BioLabs, Beverly, MA). PFGE was done (CHEF-DR III system; Bio-Rad, Richmond, CA) with a ramp time of 5–50 s at 200 V for 22 h. Isolates were defined as belonging to the same subtype if their PFGE patterns differed by ⩽3 bands [12].

Antimicrobial resistance. Antimicrobial resistance was tested by the disk diffusion method [13]. Three isolates from each community outbreak and 3 controls were selected on the basis of date of isolation to reflect the beginning, peak, and end of the outbreak. Isolates were tested for susceptibility to chloramphenicol, trimethoprim-sulfamethoxazole, tetracycline, ampicillin, sulfisoxazole, streptomycin, gentamicin, amoxicillin-clavulanate, and kanamycin.

Results

Shigellosis clusters were identified in traditionally observant communities in 8 of the 12 cities, with a total of >1000 culture-confirmed cases (figure 1). Investigations by local or state health departments did not identify a common source in any of these outbreaks, which lasted a median of 6 months (range, 2–10).

Epidemiologic investigation by local health departments. In the traditionally observant Jewish neighborhood of Borough Park, Brooklyn, New York, 362 cases of *S. sonnei* infection were reported between 1 August 1994 and August 1995, with a peak of 48 reported cases in the week of 27 November 1994. By comparison, 7 cases were reported in 1993 and 6 cases in the first 7 months of 1996. Three-quarters of cases occurred in day care– or school-aged children.

Between October 1994 and July 1995, an outbreak of *S. sonnei* caused 375 cases in a traditionally observant Jewish community in Ocean County, New Jersey. An additional 14 confirmed cases were reported during September and October 1995.

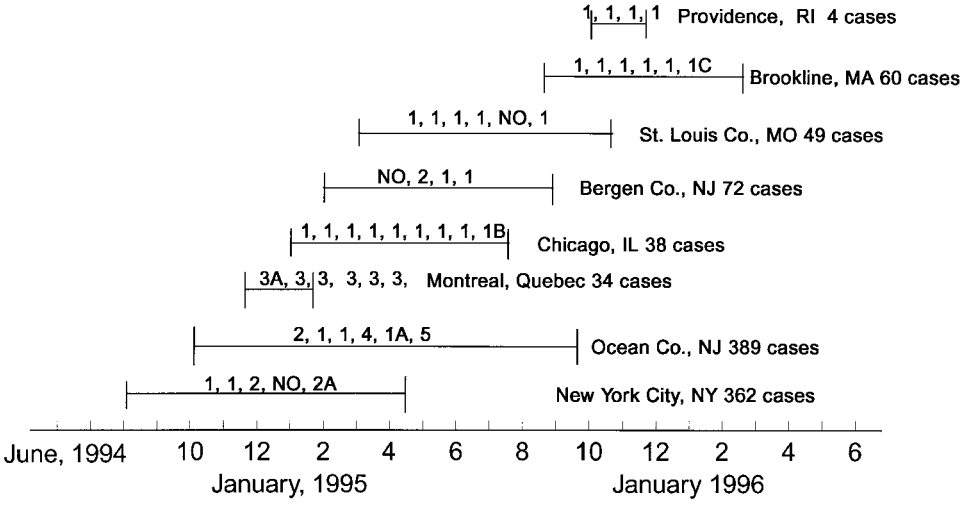

Figure 1. Time line of outbreaks of *S. sonnei* in 8 traditionally observant Jewish communities in North America, 1994–1996. Pulsed-field gel electrophoresis pattern of each subtyped isolate is indicated for each outbreak; NO = not outbreak pattern.

Between 23 November 1994 and 27 January 1995, 34 cases of *S. sonnei* infection were identified in a traditionally observant community in Montreal, Quebec; the mean age of patients was 7 years. The earliest patient had become ill while visiting relatives in New York City.

Between February and September 1995, 72 cases of *S. sonnei* infections were reported in the traditionally observant Jewish community in Bergen County, New Jersey; the outbreak was centered in four religious schools.

Between March and November 1995, 49 cases of *S. sonnei* infection were reported to the St. Louis County (Missouri) Department of Health. These cases occurred among members of a traditionally observant Jewish community living in a well-defined geographic area consisting of three census tracts within a single zip code. The median age of patients was 7 years.

Between January and August 1995, an outbreak of 38 cases of *S. sonnei* infections was reported from two Chicago Community Areas inhabited principally by a traditionally observant Jewish community. The mean age of case patients was 18 years. Only 2 culture-confirmed cases were reported in this community in 1994.

In Brookline, Massachusetts, 60 cases of *S. sonnei* infection occurred among pupils and family contacts of four religious schools between 26 August 1995 and 9 February 1996; a peak number of cases occurred between 27 October and 7 December 1995. The index patient was vacationing at a Catskill Mountains resort in New York at onset of illness.

A small cluster of shigellosis occurred in Rhode Island in October and November 1995, when a traditionally observant Jewish family of 8 moved from the Boston area to Providence. Two children in the family had had culture-positive *S. sonnei* infections before moving. Within days of moving to Rhode Island, the infection was transmitted to 2 children of another family. One of these children was attending a child care facility, where 3 cases of diarrheal illness were subsequently reported.

PFGE subtyping of isolates. Ninety-four percent (43/46) of isolates from outbreaks in traditionally observant Jewish communities in 8 cities had patterns that differed by ≤ 3 bands, meeting the definition of a single subtype, while 94% (33/35) of control isolates from 6 cities demonstrated a variety of other PFGE patterns that differed from the outbreak subtype (figure 2). One pattern (pattern 1) accounted for 65% (28/43) of outbreak isolates and was seen among isolates of all clusters except for Montreal, where only pattern 3 was encountered. The greatest variety of patterns was encountered among isolates from New York City and New Jersey (figure 1).

In 3 locations, 1 isolate linked epidemiologically to an outbreak (case isolate) had a non-outbreak PFGE pattern. Isolates from 5 patients not initially linked to the outbreak (control isolates) had outbreak PFGE patterns. Follow-up investigation revealed that 3 of these ''control'' patients were in fact members of a traditional observant community that experienced an outbreak during the period when the isolates were obtained; they were then included in the analysis as outbreak cases. The fourth had no contact with the traditionally observant Jewish community. The fifth could not be contacted.

Antimicrobial resistance. Twenty-three case isolates from the 8 communities and 16 control isolates from 6 communities were tested for antimicrobial susceptibility. Isolates from traditionally observant Jewish community outbreaks were more likely than control isolates to be resistant to trimethoprim-sulfamethoxazole (96% vs. 63%), streptomycin (100% vs. 50%), and gentamicin (39% vs. 6%). Seventeen (74%) outbreak isolates and 9 (56%) control isolates were resistant to both trimethoprim-sulfamethoxazole and ampicillin.

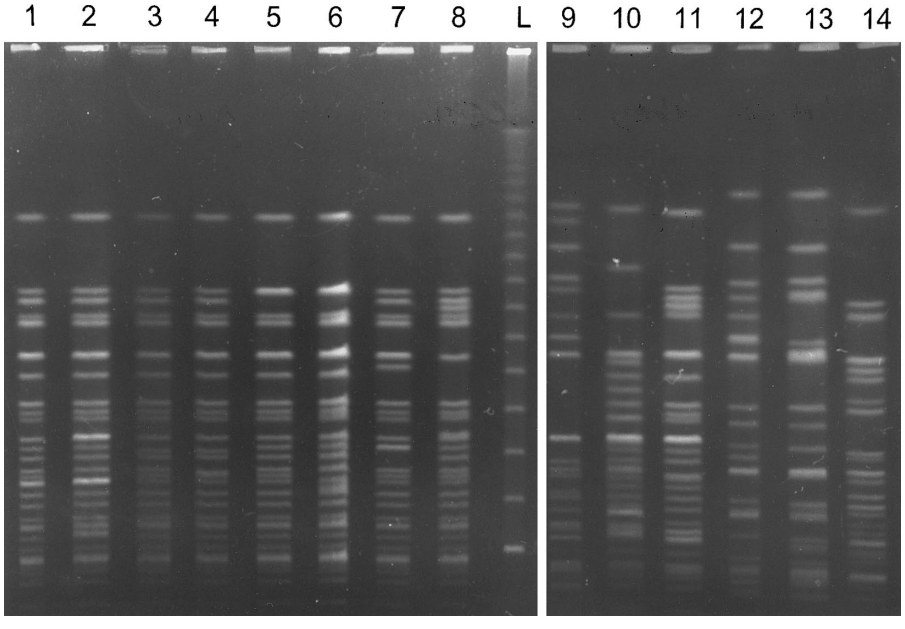

Figure 2. Pulsed-field gel electrophoresis patterns from *S. sonnei* isolates. Lanes 1–8: Representative isolates of outbreak patterns 1 (Chicago), 1A (Ocean County, NJ), 2 (New York City), 2A (New York City), 3 (Montreal), 3A (Montreal), 4 (Ocean County, NJ), 5 (Ocean County, NJ). Lanes 9–14: Patterns of controls from Chicago; Ocean County; Montreal; Brookline, Massachusetts; Providence, Rhode Island; and Chicago.

Discussion

Clusters of *S. sonnei* infection in 8 traditionally observant Jewish communities in North America were caused by a single subtype of *S. sonnei* that exhibited multiple, highly related PFGE patterns. These clusters thus represent a single, protracted international outbreak that spread among these communities independent of other *S. sonnei* infections occurring in the same cities. Some of these communities were affected by a similar, though less extensive, *S. sonnei* outbreak in 1986 [7].

Investigations by local health departments uncovered no common vehicle, and some evidence suggested person-to-person transmission by travelers. The laboratory findings support the available epidemiologic evidence suggesting that the outbreak spread by intercommunity person-to-person contact. This suggests a pattern in which frequent contact between members of culturally similar but geographically dispersed communities that are relatively isolated from the populations that surround them produces a ''global neighborhood,'' within which enhanced social interaction is accompanied by potential transmission of infectious agents. Other poorly characterized risk factors within individual communities appear to create conditions favorable to local spread of the organism; investigations by public health officials, community members, and clinicians are needed to better define these risk factors.

In a period of sustained transmission of *S. sonnei,* a clone of an organism readily capable of acquiring antimicrobial resistance via plasmid transfer may be subjected to intense, protracted exposure to antimicrobial agents. Over the past 2 decades, antimicrobial-resistant *S. sonnei* has emerged throughout the world and in the United States [4, 14]. Although outbreak-related isolates were more resistant to a greater number of agents, both outbreak and control isolates were commonly resistant to trimethoprim-sulfamethoxazole and ampicillin, two agents that until recently were recommended as first-line therapy for shigellosis.

Traditionally, *S. sonnei* infections have been treated with antimicrobial agents to reduce the duration of illness and decrease the duration of shedding [1]. Under outbreak conditions, however, the advantage of antimicrobial therapy for individual patients must be balanced against the demonstrated risk of promoting multiply resistant bacterial strains. Preventing shigellosis in the traditionally observant Jewish communities is more important than ever because of increasing drug resistance in *Shigella* species, and reducing the risk of transmission must incorporate targeted hygienic measures [15]. Frequent, careful hand washing with soap and running water is the single most effective measure in decreasing transmission. Hygienic practices must be emphasized at home, in child care facilities and schools, and in all situations involving food handling.

PFGE appears to be a highly sensitive method of subtyping *S. sonnei.* The presence of an outbreak subtype consisting of multiple, highly related PFGE patterns may indicate that genetic material was added, deleted, or rearranged over the course of the sustained outbreak or that a number of related strains were introduced independently but transmitted simultaneously. Pattern 1, present among isolates from all cities except Montreal and characterizing all outbreak isolates for Providence and all but 1 isolate each from Chicago, St. Louis, and Brookline, may be the most stable pattern. The exclusive presence of pattern 3 in Montreal may be due to the brief duration of the outbreak in that city, with less time to undergo changes in genetic material. The presence of multiple patterns in New York City and Bergen County and Ocean County, New Jersey, may represent a snapshot in time of genetic shifts toward the more stable configuration represented by outbreak pattern 1.

PFGE reveals and confirms patterns of transmission of *S. sonnei,* and further application will refine its sensitivity and specificity for determining the relatedness of similar gel patterns. Standardization of PFGE pattern determination for this pathogen may provide a useful public health subtyping system for *S. sonnei.*

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References

1. DuPont HL. *Shigella* species (bacillary dysentery). In: Mandell GL, Douglas RG, Bennet JE, eds. Principles and practice of infectious diseases. New York: Churchill Livingstone, **1990**:1716–22.
2. Centers for Disease Control and Prevention. *Shigella* Surveillance Annual Tabulation Summary, 1993–95. Atlanta: US Department of Health and Human Services, **1996**.
3. Centers for Disease Control. CDC news. J Infect Dis **1977**;136:458–9.
4. Griffin PM, Tauxe RV, Redd SC, Puhr ND, Hargrett-Bean N, Blake PA. Emergence of highly trimethoprim-sulfamethoxazole resistant *Shigella* in a Native American population: an epidemiologic study. Am J Epidemiol **1989**;129:1042–51.
5. Cook K, Boyce T, Puhr N, Tauxe R, Mintz E. Increasing antimicrobial-resistant *Shigella* infections in the United States [abstract E-20]. In: Program and abstracts of the 36th Interscience Conference on Antimicrobial Agents and Chemotherapy (New Orleans). Washington, DC: American Society for Microbiology, **1996**:84.
6. Centers for Disease Control. Community outbreaks of shigellosis—United States. MMWR Morb Mortal Wkly Rep **1990**;39:509–13, 519.
7. Centers for Disease Control. Multistate outbreak of *Shigella sonnei* gastroenteritis—United States. MMWR Morb Mortal Wkly Rep **1987**;36:440–2, 448–9.
8. Hinojosa-Ahumada M, Swaminathan B, Hunter SB, et al. Restriction fragment length polymorphism in rRNA operons for subtyping *Shigella sonnei.* J Clin Microbiol **1991**;29:2380–4.

9. Brian MJ, Van R, Townsend I, Murray BE, Cleary TG, Pickering LK. Evaluation of the molecular epidemiology of an outbreak of multiply resistant *Shigella sonnei* in a day care center by using pulsed-field gel electrophoresis and plasmid DNA analysis. J Clin Microbiol **1993**;31: 2152–6.
10. Liu PYF, Lau YJ, Hu BS, et al. Analysis of clonal relationships among isolates of *Shigella sonnei* by different molecular typing methods. J Clin Microbiol **1995**;33:1779–83.
11. Bohm H, Karch K. DNA fingerprinting of *Escherichia coli* O157:H7 strains by pulsed-field gel electrophoresis. J Clin Microbiol **1992**;30: 169–72.
12. Tenover FC, Arbeit RD, Goering RV, et al. Interpreting chromosomal DNA restriction patterns produced by pulsed-field gel electrophoresis: criteria for bacterial strain typing. J Clin Microbiol **1995**;33:2233–9.
13. National Committee for Clinical Laboratory Standards. Performance standard for antimicrobial disk susceptibility tests: approved standard, M2-A5. Villanova, PA: National Committee for Clinical Laboratory Standards, **1993**.
14. Tauxe RV, Puhr ND, Wells JG, Hargrett-Bean N, Blake PA. Antimicrobial resistance of *Shigella* isolates in the USA: the importance of international travelers. J Infect Dis **1990**;162:1107–11.
15. Tuttle J, Tauxe RV. Antimicrobial-resistant *Shigella:* the growing need for prevention strategies. Infect Dis Clin Pract **1992**;2:55–9.