MAJOR ARTICLE

Epidemiologic Investigation and Targeted Vaccination Initiative in Response to an Outbreak of Meningococcal Disease among Illicit Drug Users in Brooklyn, New York

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Background. An outbreak of serogroup C meningococcal disease that involved illicit drug users and their contacts occurred in Brooklyn, New York, during 2005 and 2006.

Methods. The objectives of this study were to identify the population at risk for meningococcal disease, describe efforts to interrupt disease transmission, and assess the impact of a vaccine initiative. Descriptive and molecular epidemiological analysis was used to define the extent of the outbreak and the common risk factors among outbreak-related cases. A vaccine initiative that used community-based service providers was targeted to illicit drug users and their close contacts. The vaccine initiative was assessed through cessation of outbreak-related cases and the reduction in carriage rate.

Results. The investigation identified 23 outbreak-related cases of serogroup C meningococcal disease; 17 isolates were indistinguishable and 4 isolates were closely related according to pulsed-field gel electrophoresis. Two additional culture-negative cases had epidemiological links to laboratory-confirmed cases. The median age of patients with outbreak-related cases was 41 years, and 19 (83%) of 23 patients reported an association with illicit drug use. There were 7 outbreak-related deaths. Vaccination was administered to 2763 persons at 29 community locations, including methadone treatment centers, syringe-exchange programs, and soup kitchens. Three additional cases of meningococcal disease due to strains with the same pulsed-field gel electrophoresis pattern were identified after the vaccination initiative.

Conclusions. Community-based outbreaks of meningococcal disease are difficult to control, and the decision to vaccinate is not straightforward. Current national guidelines for implementing a vaccination campaign are not strict criteria and cannot be expected to accommodate the myriad of factors that occur in community-based invasive meningococcal disease outbreaks, such as the inability to enumerate the population at risk.

Meningococcal disease is a severe bacterial infection that, although rare, provokes concern in an affected community. *Neisseria meningitidis* possesses a polysaccharide capsule that is integral to its pathogenicity and forms the basis for subclassification of the organisms into serogroups [1]. Most (98%) of the cases in the United States are sporadic [2]. Outbreaks are most often caused by serogroup C and can occasionally be caused by serogroups B, Y, and W135 [2, 3]. The incidence of invasive meningococcal disease in the United States ranges from 0.5–1.1 cases per 100,000 population

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per year [4]; in New York City, the incidence ranged from 0.4 to 1.2 cases per 100,000 population per year (mean incidence, 0.67 cases per 100,000 population per year) during 1989–2000 [5]. Other than 8 cases due to serogroup W135 that were associated with returning Hajj pilgrims during 2000–2001 [6], there has not been an outbreak of meningococcal disease in New York City in >25 years. Traditional risk factors for meningococcal disease include household contact with a known patient, crowding, exposure to tobacco smoke, viral upper respiratory infection, asplenia, and complement deficiencies. Two vaccines are available in the United States for the prevention of meningococcal disease. Meningococcal polysaccharide vaccine is approved for use for individuals ⩾2 years of age. Meningococcal conjugate vaccine (MCV4) was licensed in 2005 and is approved for use in individuals who are 2–55 years of age. Both vaccines are quadrivalent and confer protection against serogroups A, C, Y, and W135. An expected benefit of MCV4 is herd immunity through reduced rates of pharyngeal carriage [4].

From November 2005 through November 2006, an outbreak of a clonal strain of serogroup C meningococcal disease (SGC) occurred in a contiguous 4–zip code area of central Brooklyn, New York, and primarily affected persons who used illicit drugs and their close contacts. This report summarizes the descriptive and molecular epidemiology of the SGC outbreak, as well as the prevention and control measures that were implemented, which included an oropharyngeal carriage survey to assess the effectiveness of the vaccination campaign on meningococcal carriage.

PATIENTS AND METHODS

Case ascertainment and descriptive epidemiology. All case reports were investigated by confirmation of laboratory results, interviews with health care providers, administration of a standard questionnaire to the patient (if possible), and interviews of family members and close contacts. Antibiotic prophylaxis was offered to individuals who were found to be at an increased risk of infection [4]. After an increase in the incidence of meningococcal cases in central Brooklyn was recognized among persons who use illicit drugs in February 2006, a supplementary questionnaire was used to identify unrecognized contacts among the patients, including drug-sharing partners. A confirmed case of invasive meningococcal disease was defined as a clinically compatible illness in a resident of New York City with isolation of *N. meningitidis* in culture of a sample obtained from a normally sterile body site. A probable case was defined as a clinically compatible illness in a resident of New York City with either (1) detection of *N. meningitidis* DNA by PCR of a sample obtained from a normally sterile site, (2) a CSF sample positive for *N. meningitidis* by latex agglutination testing, (3) purpura fulminans, or (4) an epidemiologic link to a confirmed case. Primary, coprimary, and secondary cases were classified according to published criteria [4].

An outbreak-related case was defined as either (1) a culture-confirmed case with an isolate PFGE pattern with >85% similarity to that of the outbreak strain and occurring from 1 November 2005 through 30 November 2006, or (2) a culture-negative case meeting the probable case definition and epidemiologically linked to a confirmed outbreak case by household or other contact occurring from 1 November 2005 through 30 November 2006. We compared clinical and demographic characteristics of SGC outbreak-related cases with characteristics of meningococcal cases due to serogroups B, Y, and W135 that occurred during the same period.

Vaccination initiative. The target population for vaccination were adults (>18 years of age) living in 1 of 4 central Brooklyn zip codes with a history of illicit drug use (cocaine, crack cocaine, or heroin) or methadone use in the previous 3 months and the household contacts (age, ⩾2 years) of persons with a history of illicit drug use. Minimal data were gathered (age group, vaccine type, and facility) to diminish barriers to vaccination. Vaccination was offered at community health centers, methadone maintenance treatment programs, syringe exchange programs, day or residential drug treatment programs, soup kitchens, homeless shelters, correctional health care facilities, and outpatient clinical sites. MCV4 was offered to all individuals who were 11–55 years of age. Meningococcal polysaccharide vaccine was offered to individuals aged 2–10 years or >55 years, because MCV4 was not licensed for these age groups.

Evaluation. To evaluate the effectiveness of the vaccination campaign we conducted an oropharngeal carriage survey of *N. meningitidis* in the target population. The carriage survey was designed to measure prevaccination and postvaccination carriage rates of the vaccine serogroups (A, C, Y, and W135). All persons eligible for meningococcal vaccination were eligible for the carriage survey. Participation was voluntary, anonymous, irrespective of intent to be vaccinated, and limited to only 1 person per household. Participants or parents signed informed consent forms and completed a self-administered questionnaire collecting information on demographic characteristics, prior meningococcal vaccination, cigarette smoking, household size, and illicit drug or methadone use or contact with an illicit drug user. Bureau of School Health nurses were trained in the proper technique for obtaining a retrouvular pharyngeal swab sample (to improve recovery of *N. meningitidis*). No treatment was recommended either at the time of sample collection or upon return of results.

Prevaccination carriage prevalence was estimated at 6%. To detect a 50% reduction in carriage after vaccination, we estimated that 2000 participants were needed for each phase of the survey.

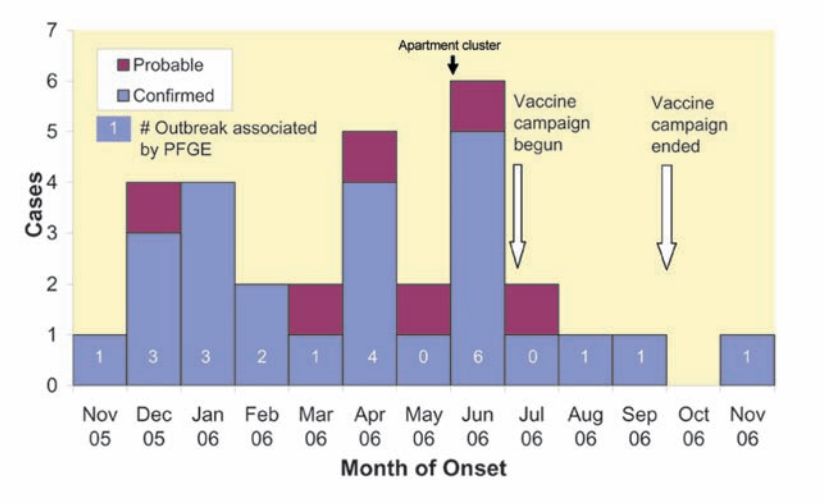

Figure 1. Outbreak curve displaying serogroup C meningococcal disease cases in New York City, November 2005 through November 2006

Laboratory testing. All *N. meningitidis* isolates were identified using standard methods, including Gram stain, oxidase testing, cystine tryptic agar sugars, and API NH test strips (bioMérieux). Clinical specimens (e.g., blood, serum, and CSF samples) from patients with negative culture results were sent to the Wadsworth Center, New York State Department of Health (Albany, New York), for testing by a novel multiplex real-time PCR assay that uses Taqman chemistry and targets the capsule biosynthesis genes and serogroup-specific (A, B, C, Y, and W135) capsular genes.

Carriage survey oropharyngeal swab samples were immediately inoculated onto Jembec plates (Becton Dickinson) in the field. Several quality-control checks were performed by spiking samples with stock cultures to assure the ability to isolate *N. meningitidis* when present. These checks focused on Jembec plate handling, storage, and transport; in all experiments, *N. meningitidis* grew well when it was present.

Meningococcal patient isolates were sent to the Public Health Laboratory for serogrouping and PFGE analysis. Additional molecular typing by PCR, repeat PFGE, and multilocus sequence typing was performed at the Centers for Disease Control and Prevention in Atlanta, Georgia. *N. meningitidis* isolates were serogrouped by slide agglutination and PCR, with serogroup-specific primers for serogroups A, B, C, W135, X, and Y (Mothershed). Typing was performed by PFGE with use of *Nhe*I (New England BioLabs) restriction enzyme, as described elsewhere [7]. Analysis of PFGE gel images used BioNumerics software, version 4.0 (Applied Maths). Multilocus sequence typing, with use of the Multi Locus Sequence Typing Web site [8] to assign alleles and sequence types, was also performed [9, 10].

Data analysis. Descriptive statistics and nonparametric analyses were performed with SAS, version 9.1 (SAS Institute), and SPSS software, version 13.0 (SPSS). Associations were considered to be statistically significant if $P < .01$.

RESULTS

Case ascertainment and descriptive epidemiology. In total, 31 cases (29 primary cases and 2 secondary cases) of SGC occurred in New York City during the outbreak period; of these 31 cases, 25 were confirmed, and 6 were probable cases (onset ranged from 12 November 2005 through 6 November 2006). In contrast, a mean of ~10 cases of SGC occurred annually in New York City in earlier years. Of these 31 cases of SGC, 23 were determined to be outbreak related. The index case occurred in a 47-year-old woman from the Bronx with symptom onset on 12 November 2005. The patient reported frequent visits to Brooklyn and was retrospectively linked to the outbreak by PFGE analysis. Sixteen cases (70%) occurred in 4 contiguous zip codes in central Brooklyn. Two secondary cases were identified, as were 3 coprimary cases. One secondary case and the cluster of 3 coprimary cases occurred in early June in residents of 3 different apartments in the same building (figure 1).

The median age of individuals with outbreak-related cases was 41 years (range, 4–68 years), and 57% of patients were female. Eighteen (78%) of the patients were black or African-American, 2 (9%) were white/Hispanic, 2 (9%) were white/non-Hispanic, and 1 (4%) was white/unknown ethnicity. The case-fatality rate among patients with outbreak-associated cases was 30% (7 of 23 patients died). Nineteen (83%) of the patients reported an association with illicit drug use. Eleven patients (48%) were current or former illicit drug users, and 8 (35%) reported contact (household contact or other frequent contact) with illicit drug users. Cocaine (including crack cocaine) was the most common illicit drug associated with outbreak cases

and was reported as a risk factor by just over one-half of patients (10 of 19 patients). Demographic and clinical characteristics of all individuals with cases of SGC are presented in table 1.

We compared the characteristics of the 23 outbreak-related cases of SGC with those of 26 sporadic cases of invasive meningococcal disease due to other serogroups that occurred during the same time period (November 2005 through November 2006). Of these 26 sporadic non-SGC meningococcal cases, 21 were culture confirmed (11 cases due to serogroup B, 9 due to serogroup Y, and 1 due to serogroup W135), and 5 were identified by PCR (3 cases due to serogroup B and 2 cases due to serogroup Y). The median age of patients with non-SGC cases was 24 years (range, 6 months through 95 years), and 15 (58%) of the patients were male. There were no deaths among individuals with non-SGC cases. Patients with outbreak-related SGC cases differed significantly from patients with non-SGC cases, in that they were more likely to be African-American or black and more likely to be residents of Brooklyn (specifically, residents of the contiguous Brooklyn zip codes) and to have died as a result of meningococcal infection (table 2). Figure 2 presents a density map of meningococcal cases due to serogroups C, B, and Y for New York City during the outbreak period and highlights the focality of the outbreak. Information on illicit drug use was not routinely collected for all cases, so comparisons were not possible.

Vaccination initiative. The targeted vaccination campaign operated from 28 June 2006 through 30 September 2006 and vaccinated 2763 individuals. MCV4 was given to 2406 (87%) of those who received vaccine. The proportion of individuals vaccinated at each site type was as follows: 25% at methadone

Table 1. Demographic and clinical characteristics of patients with cases of serogroup C meningococcal disease, New York City, November 2005–November 2006.

Case ID number	Patient age, years	Sex	Race	Residence	Date of onset	Secondary case (primary case number)	Illicit drug use or contact	Outcome	Case confirmation	Syndrome	Outbreak related
1	47	F	Black	Bronx	12 Nov 2005	No	3	Alive	Confirmed	M	Yes
2	32	F	White	Brooklyn	18 Dec 2005	No	3	Alive	Probable[a]	M, P	Yes
3	42	M	Black	Brooklyn	20 Dec 2005	No	3	Alive	Confirmed	B, P	No
4	4	M	Black	Brooklyn	22 Dec 2005	No	2	Alive	Confirmed	M, B	Yes
5	32	F	White	Brooklyn	22 Dec 2005	Yes (2)	3	Alive	Confirmed	M, B	Yes
6	40	M	White	Brooklyn	12 Jan 2006	No	3	Died	Confirmed	C	Yes
7	6	M	Black	Brooklyn	18 Jan 2006	No	2	Alive	Confirmed	B	Yes
8	80	F	Black	Brooklyn	18 Jan 2006	No	1	Died	Confirmed	C, P	No
9	48	F	Black	Brooklyn	28 Jan 2006	No	3	Died	Confirmed	M, C	Yes
10	66	M	Black	Brooklyn	3 Feb 2006	No	2	Died	Confirmed	C	Yes
11	43	F	Black	Brooklyn	24 Feb 2006	No	3	Alive	Confirmed	M, B	Yes
12	49	M	Black	Brooklyn	13 Mar 2006	No	2	Died	Confirmed	M, B	Yes
13	9	M	White	Brooklyn	26 Mar 2006	No	1	Alive	Probable[b]	M, B	Unknown
14	41	M	White	Brooklyn	1 Apr 2006	No	1	Alive	Confirmed	M, B	Yes
15	13	M	Black	Brooklyn	11 Apr 2006	No	1	Alive	Confirmed	M, B	Yes
16	46	F	Black	Brooklyn	13 Apr 2006	No	3	Died	Confirmed	C	Yes
17	32	M	Black	Brooklyn	15 Apr 2006	No	3	Alive	Probable[b]	M	Unknown
18	43	F	Black	Brooklyn	24 Apr 2006	No	3	Died	Confirmed	C	Yes
19	59	F	White	Brooklyn	1 May 2006	No	1	Alive	Probable[b]	M, C	Unknown
20	31	M	Asian	Brooklyn	31 May 2006	No	3	Alive	Confirmed	P, J	No
21	46	F	Black	Brooklyn	4 Jun 2006	Coprimary	3	Died	Confirmed	C	Yes
22	12	F	Black	Brooklyn	5 Jun 2006	Coprimary	2	Alive	Confirmed	M, C	Yes
23	21	F	Black	Brooklyn	5 Jun 2006	Coprimary	2	Alive	Confirmed	M, C	Yes
24	11	F	Black	Brooklyn	6 Jun 2006	Yes (22)	2	Alive	Probable[b]	B	Yes
25	42	F	Black	Brooklyn	25 Jun 2006	No	1	Alive	Confirmed	B	Yes
26	68	M	White	Florida[c]	27 Jun 2006	No	3	Alive	Confirmed	B, J	Yes
27	31	M	Black	Brooklyn	1 Jul 2006	No	3	Alive	Probable[b]	M, C	Unknown
28	1	F	Asian	Queens	15 Jul 2006	No	1	Alive	Confirmed	B	No
29	43	M	Black	Brooklyn	5 Aug 2006	No	3	Alive	Confirmed	C, P	Yes
30	6	M	Black	Brooklyn	27 Sep 2006	No	1	Alive	Confirmed	B	Yes
31	30	F	Black	Brooklyn	6 Nov 2006	No	2	Alive	Confirmed	B	Yes

NOTE. 1, No reported illicit drug use or contact with illicit drug user; 2, no reported illicit drug use but contact with illicit drug user; 3, reported current or former or laboratory evidence of illicit drug use; ; B, bacteremia; C, meningococcemia; J, septic arthritis; M, meningitis, P, pneumonia.

[a] By epidemiological link to confirmed case.

[b] By PCR results positive for *Neisseria meningitidis* serogroup C.

[c] Had been resident in Brooklyn for 2 weeks at the time of illness.

Table 2. Characteristics of outbreak-associated cases of serogroup C meningococcal disease, compared with characteristics of non–outbreak-associated cases of serogroup B, serogroup Y, and serogroup W135 meningococcal disease, New York City, November 2005–November 2006.

Variable	Outbreak-associated cases (n = 23)	Non–outbreak-associated cases (n = 26)	P
Age, median years	41	24	.39
Female sex	13/23 (57)	11/26 (42)	.37
Black race	18/23 (78)	4/26 (15)	<.01
Residence in Brooklyn	21/23 (91)	5/26 (19)	<.01
Residence in target zipcodes	16/23 (70)	0/26 (0)	<.01
Meningococcemia	9/23 (39)	4/26 (15)	.11
Time from symptom onset to hospital admission, mean days ± SD	2.3 ± 3.1	1.8 ± 4.3	.64
Close contacts identified, mean no. ± SD	21.7 ± 33.4	9.2 ± 10.8	.02
Survival	14/23 (61)	26/26 (100)	<.01

NOTE. Data are proportion (%) of cases, unless otherwise indicated.

maintenance treatment programs (4 sites), 22% at homeless shelters (6 sites), 22% through syringe exchange programs (3 sites), 15% through outpatient medical clinics (6 sites), 5% at residential drug treatment facilities (4 sites), 5% at soup kitchens (2 sites), 4% through correctional health (1 site), and 2% through inpatient medical facilities (3 sites). One vaccine adverse event was reported; a case of Guillain-Barré syndrome was diagnosed in a 30-year-old man 9 days after vaccination who required hospitalization and recovered completely.

Five cases due to serogroup C occurred during the 5 months after the initiation of the vaccination campaign (figure 1). Four of them (3 confirmed cases and 1 probable case) occurred in the 4–zip code epicenter of the outbreak. The isolates obtained from the 3 patients with confirmed cases were indistinguishable from the outbreak strain. Two cases (cases 29 and 31) occurred in individuals who had a connection to the illicit drug user community, and none of the 4 patients received meningococcal vaccine during the campaign.

Evaluation. Seventy percent of the participants (982 of 1403) in the prevaccination survey were from the targeted zip codes, and 50% of those who completed the questionnaire (650 of 1297) reported illicit drug use or living with a drug user. *N. meningitidis* was isolated from 19 (1.4%) of 1403 persons from whom swab samples were obtained during the prevaccination carriage survey. One isolate was SGC and was indistinguishable from the outbreak strain. It was recovered from a 46-year-old woman who lived in a targeted zip code and reported illicit drug use and sharing of illicit drug use equipment. Because of a lower-than-expected prevaccination carriage rate and the low likelihood of demonstrating a 50% reduction in carriage, the postvaccination carriage survey was cancelled.

Laboratory. Molecular subtyping was performed for all 25 isolates from laboratory-confirmed cases; 17 isolates were indistinguishable and 4 were closely related by PFGE (figure 3). The 21 isolates of the outbreak strain all belonged to multilocus sequence type ST-11 complex.

DISCUSSION

We describe, to our knowledge, the largest outbreak of invasive meningococcal disease in New York City in >25 years, with 23 outbreak-related cases of SGC and 7 deaths over a 13-month period. This community-based outbreak among illicit drug users and their contacts presented considerable challenges to the public health system. Despite intensive contact tracing and prophylaxis, cases continued throughout the spring of 2006. Illicit drug use as a common characteristic prompted concern that social networks within the illicit drug user community in this area of Brooklyn were contributing to meningococcal transmission. Furthermore, the occurrence of cases outside of the household raised concerns that prophylaxis that was limited to household contacts and other traditional close contacts alone would not interrupt transmission. Population-based attack rates were computed at several intervals during the outbreak to determine whether the rates met guidelines for implementing a meningococcal vaccination control program. The primary case attack rate for the 4 Brooklyn zip codes did not exceed 2 cases per 100,000 population in any 3-month period (the Advisory Committee on Immunization Practices recommended threshold for considering vaccination to control meningococcal outbreaks is a primary attack rate of 10 cases per 100,000 population over a 3-month period) [4]. It was not possible to definitively enumerate the number of illicit drug users and their close contacts to determine whether the threshold was met for the target population of our vaccine initiative.

Illicit drug use has infrequently been reported in association with invasive meningococcal disease outbreaks, and published reports have only involved marijuana smoking [11, 12]. Both

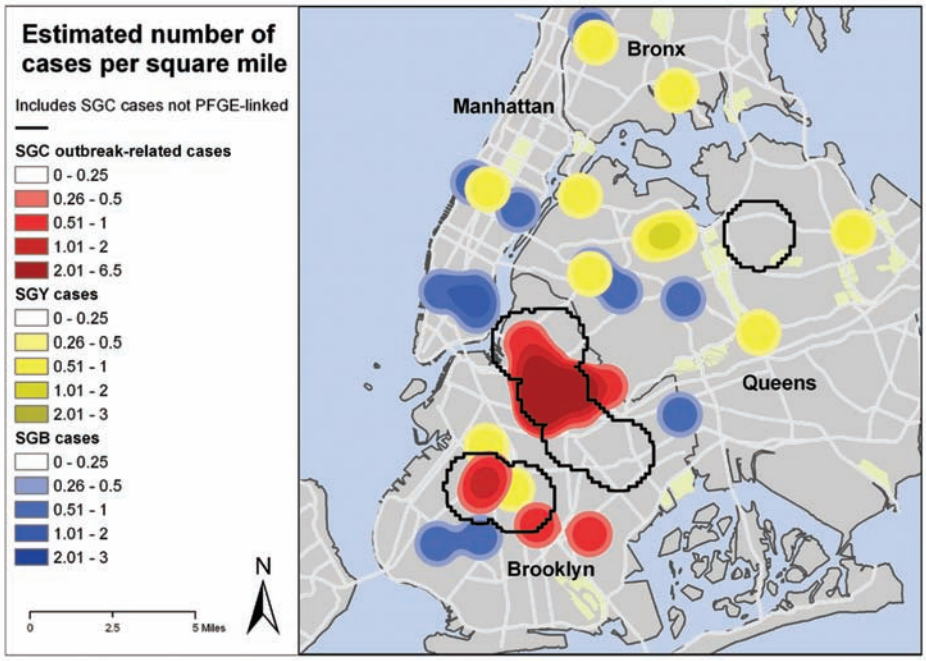

Figure 2. Density map of cases due to meningococcal serogroup B (SGB), serogroup C (SGC), and serogroup Y (SGY) in New York City, November 2005 through November 2006 (cases per square mile).

of these reports involved SGC outbreaks, and in 1 outbreak, the sharing of marijuana at a party was implicated. The investigators sought to broaden the use of antibiotic prophylaxis through identifying contacts in social networks. In the present outbreak, we attempted to identify similar networks of illicit drug users for targeting our antibiotic prophylaxis efforts but were hindered by the reluctance of patients and contacts to name their associates. A recent investigation into risk factors for sporadic invasive meningococcal disease among teenagers found an association with marijuana use [13]. The mechanisms by which drug use may contribute to carriage, meningococcal transmission, or development of invasive meningococcal disease are unknown. Transmission occurs during prolonged or close contact with respiratory droplets or oropharyngeal secretions. Sharing of drugs or paraphernalia or prolonged close contact among groups of illicit drug users may increase risk. The only individual identified as a carrier of the outbreak strain reported both illicit drug use and sharing of drug equipment. Cigarette smoking is associated with both carriage and invasive disease [4, 14, 15]. Data on cigarette smoking in meningococcal cases in New York City was incomplete and was not included in the analysis. Although the sharing of cigarettes has been considered to be a risk factor for meningococcal disease transmission, a study examining the role of saliva suggests the risk is not from the exchange of saliva [16]. Epidemiologic studies have consistently found that cigarette smoking is a risk factor for both carriage and invasive disease and that the common mechanism may be damage to the respiratory mucosa. Similarly, inhalation of cocaine damages the respiratory tract mucosa and may facilitate invasion [17]. Furthermore, both opiates and marijuana have been implicated as immunosuppressors in humans and animals [18–20]. This phenomenon, combined with a greater probability of exposure during an outbreak affecting illicit drug users, could explain the observed clustering of cases within the illicit drug–using community.

Our finding of a very low rate of SGC meningococcal carriage in the context of an ongoing outbreak is consistent with previous outbreaks [21–23]. However, the overall low meningococcal carriage rate (1.4%) was surprising. In industrialized countries, carriage of *N. menigitidis* increases during the second decade of life and decreases thereafter [24–26]. Participants in the carriage survey were more likely to be older, which might explain the low prevalence of carriage. This low carriage rate precluded us from performing the postvaccination survey to assess the impact of MCV4 on acquisition of carriage and transmission during a meningococcal disease outbreak. Experience in the United Kingdom, Canada, and Spain with a SGC protein conjugate vaccine suggests that the vaccine is highly effective in reducing disease in vaccinated groups and in producing herd immunity in unvaccinated cohorts [27, 29].

The vaccination campaign was undertaken after considerable discussion among senior department leadership and the Centers for Disease Control and Prevention in the spring of 2006. Among the issues discussed were the difficulties in defining and

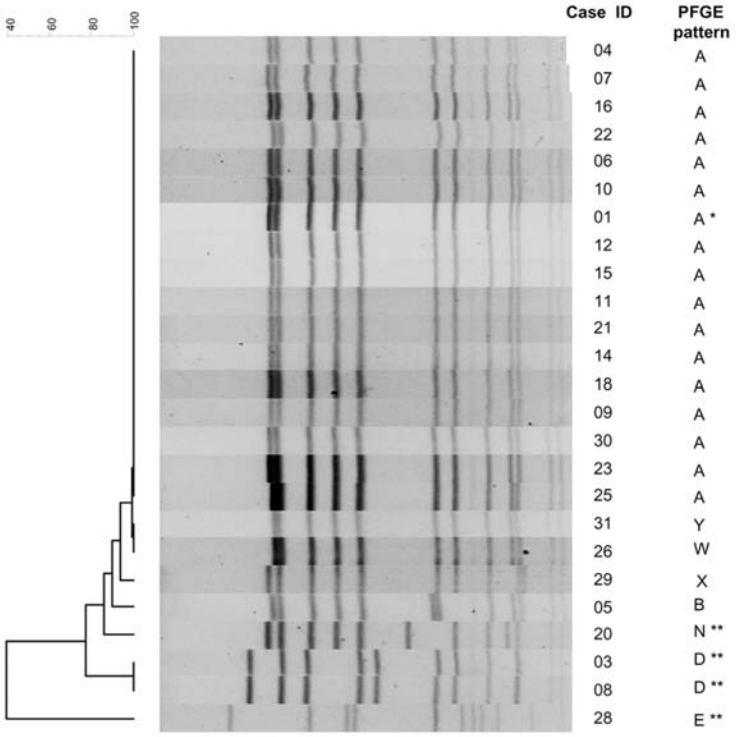

Figure 3. Dendrogram showing genetic relationships of *Nhe*I PFGE profiles of *Neisseria meningitidis* serogroup C isolates from the New York City outbreak of meningococcal disease among illicit drug users. Case identification numbers and PFGE pattern profiles are listed. *Index case isolate; **isolate not considered to be part of the outbreak.

reaching the target population, whether a limited vaccination campaign would affect the course of the outbreak, and the availability of staff and other resources to implement the campaign, including the accessibility of an adequate supply of vaccine. Our decision to vaccinate was ultimately based on the continuing occurrence of cases (including the cluster of coprimary cases at an apartment building), the high mortality rate, and the need to respond to the concerns of the community, even if we could not completely define the affected population. The vaccination campaign required substantial allocation of capital and human resources; vaccine cost and staff salary to support the vaccination campaign exceeded $1,000,000. Although sporadic cases of outbreak-related SGC continued to occur after the vaccination campaign began, the last case in an illicit drug user from central Brooklyn occurred during August 2006. The reasons for the cessation of the outbreak cannot be determined; however, potential contributing factors include seasonal and other natural variations in carriage and exposure, as well as the development of both individual and herd immunity derived naturally and, less likely, acquired through vaccination.

The vaccination initiative helped to allay community concerns about the outbreak and to establish relationships with community partners, especially at sites that served illicit drug users, which allowed us to address other public health vaccination priorities, including the promotion of hepatitis B and influenza vaccination. The vaccination initiative also provided the opportunity to test the ability of the department to mobilize and to respond to an emergency, including mass vaccination, community outreach, and education.

Community-based invasive meningococcal disease outbreaks pose arduous challenges to public health. Guidelines for implementing vaccination are not strict criteria and cannot be expected to accommodate the myriad of factors that occur in community-based invasive meningococcal disease outbreaks, such as the inability to enumerate the population at risk. Recent Advisory Committee on Immunization Practices recommendations for universal vaccination of persons 11–12 years of age with MCV4 may, over time, decrease the incidence of meningococcal disease and ameliorate these challenges.

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