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Outbreak of Serogroup C Meningococcal Disease Associated with Campus Bar Patronage

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Between February 1991 and April 1992, eight undergraduates at a US residential university and one at a nearby 2-year college contracted serogroup C meningococcal disease. A case-control investigation with 20 controls per case, oropharyngeal carriage surveys, and multilocus enzyme electrophoresis (MEE) of serogroup C isolates were used to identify factors contributing to the outbreak. All eight sterile-site isolates from cases were closely related by MEE and were similar (though not identical) to the strain associated with the 1991–1992 epidemic of meningococcal disease in eastern Canada. Disease was associated with cigarette smoking (p = 0.012), recent patronage of campus-area bars (p = 0.034), estimated amount of time spent in campus-area bars (p = 0.0003), and, especially, recent patronage of one specific bar, bar A (p = 0.0006; odds ratio = 23.1, 95% confidence interval 3.0–571.5). In carriage surveys, 1,528 throat cultures taken from (primarily student) noncases yielded only five (0.3%) strains that were identical by MEE to those from cases. Two of these were found among 22 cultures obtained from bar A employees in spring 1992. Some cases in this outbreak may have followed transmission of the epidemic strain in bar A. Campus bar environments may facilitate the spread of meningococcal disease among teenagers and young adults. *Am J Epidemiol* 1996;143:624–30.

alcohol drinking; case-control studies; disease outbreaks; meningococcal infections; *Neisseria meningitidis*; smoking; social environment; students

Serogroup C *Neisseria meningitidis* causes approximately half of the estimated 2,700 cases of invasive meningococcal disease (IMD) that occur annually in the United States (1). Although the vast majority are isolated cases, the frequency of serogroup C outbreaks in the United States roughly quadrupled in the early 1990s (1). Such outbreaks have been reported among military recruits (2), grade school students (3–5), and the general public (6, 7). In community outbreaks, the proportionate incidence of IMD among 15- to 24-year-olds is over three times that observed among sporadic cases (1). Of 12 recorded US outbreaks since 1990 (1), three were confined to this age group. This report concerns the largest of these outbreaks.

Within 48 hours in February 1991, two undergraduates at a large residential university developed IMD, and each died within 1 day of hospital admission. In late March, a student at a nearby 2-year community college was also diagnosed with IMD and subsequently recovered. From September 1991 through January 1992, one university undergraduate per month developed IMD. Serogroup C organisms were recovered from all but one patient. As cases occurred, rifampin prophylaxis was offered to the patients' close contacts, and intensive public education efforts were employed to increase the public's awareness of the early symptoms of IMD.

The seven university cases that occurred between February 1991 and January 1992 in an undergraduate resident population of about 25,000 far exceeded the national endemic level of approximately five cases of serogroup C IMD per million 18- to 22-year-olds per year (8–10). To prevent additional cases, in February 1992 the university recommended that undergraduates

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Abbreviations: CI, confidence interval; ET, enzyme type; IMD, invasive meningococcal disease; OR, odds ratio.

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receive quadrivalent meningococcal polysaccharide vaccine (which is protective against serogroups A, C, Y, and W135), and offered it without charge to students. Approximately 16,000 students were immunized within 1 month, and the program was subsequently continued with entering undergraduates. Despite this effort, in late April 1992 a student who had been immunized 8 weeks earlier developed fatal IMD. However, the only subsequent student case occurred in November 1994. The nine 1991–1992 cases form the largest reported cluster of serogroup C IMD among US college students to date.

The six survivors were interviewed in February 1992 about place of residence, membership in clubs or social groups, classes attended, athletic activities, part-time jobs, contact with other cases, and additional aspects of lifestyle. No direct link was found among these cases. One person withheld consent to report information from that interview as well as a subsequent one. However, during the 2 weeks preceding illness, the remaining five persons had all patronized campus-area bars, and four had visited one particular bar (henceforth designated bar A). Interviews with friends indicated that both of the February 1991 victims had also patronized bar A during the week prior to becoming ill. The possible relation of the outbreak to campus bar exposure was thus investigated.

MATERIALS AND METHODS

Case-control study

A case was defined by isolation of *N. meningitidis* from blood or cerebrospinal fluid, or a positive cerebrospinal fluid or blood latex agglutination test for meningococcus, in a local college student. In February 1992, 17–21 controls were interviewed for each survivor, matched according to college, sex, and year in school. University student controls were randomly selected from the university phone directory, and community college controls were chosen randomly from 46 students sampled via computer records by the college administration. Professional interviewers trained for the survey contacted controls by phone and interviewed cases in person or by phone, as convenient. Data on the April 1992 case were obtained by telephone interview of three close friends in May.

Respondents were asked to estimate their usual number of bar visits per week, and the average amount of time spent per visit, during the 2 weeks prior to onset of the matched case (the "reference period"). Cases were also asked to identify bar visits during the reference period by date, place, and duration, and controls were asked to select, from a list of nine area bars, those they were likely to have patronized during that period. Recall by 1991 university cases and matched controls was aided by a series of questions moving from the present to the semester of illness, and then to the reference period. For controls, the reference period was framed in time by its relation to a holiday or other memorable campus event. Many 1991 second-year community college students were no longer students or even living in the community when the study was conducted. Hence, spring-semester 1992 bar patronage by then-second-year students was used as control information for the March 1991 community college case.

Respondents were also asked about housing conditions, cigarette smoking, other respiratory illnesses and any medications used to treat them, crowding and smokiness at the bars they had patronized, and sharing of cigarettes or drinks at bars. The number of hours each respondent spent in bars per week was estimated by multiplying the reported average number of weekly visits by the reported average number of hours per visit.

Carriage studies

Studies were conducted to identify oropharyngeal carriers of *N. meningitidis* among students at the university student health center in February 1992, May 1992, and January 1993. Students visiting acute-care, medical, gynecologic, preventive medicine, and urgent-care clinics were asked to participate. Between mid-March and mid-May of 1992, carriage was evaluated among employees of five of the campus-area bars listed on the case-control study questionnaire. At bar A, where samples were collected during business hours, swabs were taken from curious patrons (n = 21) who volunteered. Employees were asked for demographic information similar to that obtained at the health center, as well as duration of employment, primary job, and usual shifts at each bar or restaurant where they worked. In January 1993, employees of these bars and of six others were similarly surveyed in parallel with health center clients.

Laboratory methods

Health center carriage samples in February 1992 and January 1993 were collected and processed by staff on-site, while public health district personnel collected and processed the samples from bar workers and patrons. So that the comparability of results could be checked, cultures from approximately 30 percent of the May 1992 health center subjects were taken and processed by the public health district personnel who conducted the bar surveys.

Samples collected by health center personnel were immediately taken to a laboratory within the building,

plated onto Thayer-Martin medium, and stored overnight at 37°C in a 5 percent carbon dioxide incubator. Detectable growth was tested by Gram's stain and oxidase. Specimens compatible with a *Neisseria* species were checked for carbohydrate utilization by the quadFERM+ system (Analytab Products, Plainview, New York). Samples collected by public health department personnel were plated immediately onto Martin-Lewis agar. Shortly thereafter, carbon dioxide tablets were added and plates were stored in zippered plastic food storage bags at ambient temperature. After transport to the public health laboratory, usually within 2 hours, plates were incubated at 37°C for 2 days, and detectable growth was tested by Gram's stain and oxidase.

Isolates compatible with *N. meningitidis* were transferred to chocolate agar slants, incubated for 24–48 hours, and shipped overnight to the Centers for Disease Control and Prevention for further testing. *N. meningitidis* isolates from 1992 were serogrouped by slide agglutination. Due to a shortage of reagents, serotyping of 1993 isolates was confined to identification of group C strains. Group C isolates were characterized by multilocus enzyme electrophoresis (11) with 24 enzymes, and each distinct set of alleles was used to define a numerical enzyme type. The numbers assigned were arbitrary and are unique to this study.

Statistical methods

Univariate comparisons of cases with controls used Cochran-Mantel-Haenszel tests (12, 13), with permutation rank statistics employed for multicategory and continuous variables. Conditional logistic regression (14) was used for modeling. Conditional maximum likelihood estimates were obtained for (assumed) common odds ratios. When comparing the bar exposures of cases with those of controls, we used one-sided p values, since controls were studied only because of high bar exposure among cases, and error on the opposite tail was hence impossible. Pearson's chi-square statistic was used when comparing carriage prevalences in two groups. "Exact" methods (15, 16) were employed throughout because cases and carriers were few, and p values and confidence intervals incorporate a mid-p continuity correction (15, 17, 18).

RESULTS

Case-control study

For each case, table 1 shows date of onset, age, sex, college, year in college, results of culture and latex agglutination tests, and outcome. No cases shared common housing or lived in the same dormitory. Only one case had had a respiratory infection during the 2 weeks prior to onset of meningitis. Between 17 and 21 controls were obtained per case. Four students were reported to be out of town due to family emergencies, but we reached over 86 percent of the other targeted controls, and 95 percent of those reached gave interviews. Henceforth, we exclude results from one matched set, by request of the case.

Data on bar patronage and cigarette smoking, the two exposures identified as significant risk factors, are summarized in table 2. The median estimated weekly bar exposure was 7.2 hours for cases versus 1.0 hours for controls ($p = 0.0003$). Cases estimated >4 hours' weekly exposure far more often than did controls (odds ratio (OR) = 16.7, 95 percent confidence inter-

TABLE 1. Characteristics of nine cases of meningococcal disease among college students, Champaign-Urbana, Illinois, February 1991–April 1992

Date of onset	Age (years)	Sex	Ethnicity	Type of school	Year in school	Blood culture	Cerebrospinal fluid culture	Outcome
February 8, 1991	19	Male	White	University	2	+	ND*	Died
February 10, 1991	19	Male	White	University	1	+	−†	Died
March 14, 1991	19	Male	White	Community college	2	+	−	Survived
September 11, 1991	20	Female	White	University	3	+	+	Survived
October 5, 1991	20	Male	White	University	3	+	ND	Survived
November 25, 1991	20	Female	Asian	University	3	−‡	−	Survived
December 15, 1991	22	Female	White	University	4	+	ND	Survived
January 28, 1992	18	Male	White	University	1	+	+	Survived
April 20, 1992	19	Female	White	University	2	+	−§	Died

* ND, not done.

† Postmortem culture.

‡ This patient presented with a severe frontal headache, generalized myalgia, vomiting, a fever of 38.6°C, a blood pressure of 86 mmHg/56 mmHg, a white blood cell count of 29,800 per mm^3, and 1- to 2-mm macules on the distal lower extremities. She received 500 mg of amoxicillin-clavulanate 1 hour and 45 minutes prior to the time at which blood cultures were first obtained and 4 hours prior to lumbar puncture. (The previous day, she had been placed on 250 mg of cefuroxime twice daily for presumed sinusitis, but vomited after taking the medication.) Serum latex agglutination testing was positive for a combination of antigens to *Neisseria meningitidis* serogroups C and W135.

§ Sample was refrigerated for 36 hours prior to culture.

TABLE 2. Analysis of cigarette smoking and campus bar patronage among six college students with serogroup C invasive meningococcal disease and matched controls: Champaign-Urbana, Illinois, February 1991–April 1992

Exposure	No. of exposed cases/ total no.	No. of exposed controls/ total no.*	Odds ratio	95% CI†	Exact mid-p
Cigarette smoking	4/6	23/117	7.8	1.3–64.4	0.012
Campus bar patronage (previous 2 weeks)					
Any	6/6	73/117			0.034
>4 hours/week	5/6	26/117	16.7	2.1–409.9	0.002
Bar A (any duration)	5/6	19/117	23.1	3.0–571.5	0.0006

* One hundred seventy-three potential controls were contacted. Of these, 27 were determined to be ineligible (sex incorrectly inferred from directory listing, exchange student off-campus for the semester or year, incorrect listing of year in school, or person, having left school, no longer living in the community); 10 people could not be located because the telephone directory listing was incorrect or service had been discontinued without a forwarding number, and there was no current telephone listing; and four people were reported to be off-campus for the duration of the survey (three due to serious family illness). Repeated calls to nine people were not answered and/or answering machine messages were not returned; and six people refused interviews.

† CI, confidence interval.

val (CI) 2.1–409.9; $p = 0.002$). Cigarette smoking (OR = 7.8, 95 percent CI 1.3–64.4; $p = 0.012$) also appeared to be a strong risk factor. The bar exposure and cigarette smoking effects were tested together in a conditional multiple logistic regression model, using a three-category representation of recent bar exposure (<6, 6–8, and ≥9 hours per week) and simultaneous adjustment for possible effects of both frequency of respiratory illness and number of people sleeping in the same room. Bar exposure remained statistically significant ($p = 0.019$ by the exact scores test) while cigarette smoking became marginally nonsignificant ($p = 0.1125$) with the multiple adjustment.

Bar A was the only bar individually associated with disease (OR = 23.1, 95 percent CI 3.0–571.5). This association remained highly significant after Bonferroni adjustment was made to account for simultaneous examination of nine bars (adjusted $p = 0.0054$). Five of six cases (83 percent) and 67 of 117 controls (57 percent) had frequented at least one other listed bar, a statistically nonsignificant ($p = 0.12$) difference. Mean crowding scores (1 = very crowded, 2 = somewhat crowded, 3 = not crowded) for nine bars ranged from 1.2 to 2.1, with bar A being among three bars at 1.2 and the remainder being at 1.6 or above. Mean smokiness scores (1 = very smoky, 2 = somewhat smoky, 3 = not smoky) ranged from 1.7 to 2.6, with bar A rated the smokiest.

Sharing of drinks by alcohol drinkers (OR = 4.3, 95 percent CI 0.7–36.1; $p = 0.11$) and sharing of cigarettes by cases who smoked (OR = 8.0, 95 percent CI 0.6–264.6; $p = 0.13$) exhibited high but not statistically significant odds ratios. Observed differences in respiratory illnesses, housing, and medication use were unremarkable.

Carriage studies

Of 867 university health center clients surveyed in 1992, 86 (9.9 percent) were culture-positive for *N. meningitidis*, but only 3 (0.3 percent) harbored serogroup C. Carriage was 11.1 percent in February and 9.0 percent in May ($p = 0.30$ for the change). The carriage results from public health district and health center staffs were virtually identical within health center clinics. Carriage among 344 clients in 1993 was similar to that seen in 1992: 12.2 percent overall and 0.6 percent for Group C.

In contrast, among the 85 predominantly (88 percent) student bar workers studied in 1992—ranging in age from 19 to 28 years, with 80 percent being 20–22 years of age—32 (38 percent) carried meningococcus and four (5 percent) carried serogroup C. *N. meningitidis* carriage among the 21 bar A customers tested was 24 percent, intermediate between bar workers and health center clients. Serogroup C carriage among bar workers was 13.6 times the 0.3 percent prevalence seen in health center clients ($p = 0.0009$). In January 1993, carriage prevalences were 28 percent and 1 percent for total and serogroup C carriage, respectively, among 211 workers from the larger group of bars surveyed at that time.

Serogroup C enzyme patterns detected by multilocus enzyme electrophoresis were arbitrarily designated enzyme types (ETs) 1–9. All organisms from university cases were ET1 strains, while ET2 was cultured from the community college case. Only slight differences in peptidase, fumerase, and aconitase mobilities distinguished ETs 1–4 from the 1991–1992 Canadian outbreak strain. (ET1 and ET2 isolates from cases were also similar by polymerase chain reaction fingerprinting (19).)

Table 3 summarizes carriage of serogroup C and the ETs (1 and 2) recovered from cases. A total of 973 1992 samples (867 health center clients, 85 bar workers, and 21 bar A customers) yielded only five (0.5 percent) cultures of these strains: two (0.2 percent) from health center clients and three (3.5 percent) from the bar workers, including two (9.0 percent) from 22 bar A workers. The analogous percentages for ET1 alone were 0.3 percent, 0.1 percent, 2.4 percent, and 9.0 percent. The prevalence of case-linked organisms in the 1992 studies was thus 15.3 (=3.53/0.23) times greater among bar workers ($p = 0.003$) and 39.4 (=9.09/0.23) times greater among bar A workers ($p = 0.002$) than among health center clients. These prevalence ratios double to 30.6 and 78.8, respectively, if ET1 alone is considered, since only one 1992–1993 university health center client, a recent bar patron, yielded ET1. ET2, isolated from the community college case, was found in a health center client and in one (7.1 percent) of 14 employees of bar B, which the case occasionally patronized. ETs 1–4 were absent from 555 January 1993 samples from health center clients and bar workers.

DISCUSSION

Our investigation of this large university outbreak indicated that IMD was associated with exposure to campus bars in general and to one campus bar in particular. Both bar patronage (20) and heavy alcohol use (21–23) have previously been suggested as risk factors for IMD. We did not question cases or controls about their alcohol use, and hence cannot directly address that issue. However, an association of disease with bar patronage is epidemiologically plausible, independent of alcohol exposure. IMD has been associated with crowded living conditions and restricted ventilation (2, 10, 24–26). At peak hours, student bars are exceptionally congested, which may facilitate direct droplet transmission. Spread of IMD among younger students has been reported in the less-crowded environments of classrooms (3) and school buses (5). Our data also suggest that IMD, which has previously been linked to passive smoke exposure (20, 27, 28), is additionally associated with active smoking. Crowded conditions promoting droplet transmission, increased susceptibility to invasive disease among active or passive smokers exposed to meningococcus, and elevated levels of smoking in the bar environment might jointly explain an association of disease with bar patronage.

Bar A, the specific establishment associated with this outbreak, fits this hypothesis well. In the case-control study, those controls who had recently patronized bar A almost unanimously described it as "very crowded." Bar A was also rated the smokiest of nine bars in that study. Located in the basement of a commercial building, bar A has low ceilings and consequently less volume per person when crowded than other local establishments.

Microbiologic as well as epidemiologic evidence suggests that some cases may have acquired the causal organism through contact in bar A. All cultures obtained from university cases were ET1 strains. Other ET1 strains were isolated from two of 22 bar A workers cultured in May 1992 but from only one of 1,506 other cultures taken from health center clients, bar workers, and customers in 1992–1993. Thus, strains recovered from university cases were found in bar A employees but rarely elsewhere. Six of seven university cases on whom we are free to report (including the two January 1991 fatalities) patronized bar A during the 2 weeks prior to developing illness, as compared

TABLE 3. Carriage of *Neisseria meningitidis* serogroup C and case-linked strains by bar workers and clients of a student health center, Champaign-Urbana, Illinois, February 1992–January 1993

Source	Meningococcal carriers					
	Serogroup C		ET1*		ET2	
	No.	%	No.	%	No.	%
Bar workers ($n = 296$)	6	2.0	2	0.7	1	0.3
1992—five bars ($n = 85$)	4	4.7	2	2.4	1	1.2
Bar A ($n = 22$)	3	13.6	2	9.1	0	0.0
Bar B ($n = 14$)	1	7.1	0	0.0	1	7.1
Other bars ($n = 49$)	0	0.0	0	0.0	0	0.0
1993—11 bars† ($n = 211$)	2	1.0	0	0.0	0	0.0
Health center ($n = 1,211$)	5	0.4	1	0.1	1	0.1
1992 ($n = 867$)	3	0.3	1	0.1	1	0.1
1993 ($n = 344$)	2	0.6	0	0.0	0	0.0

* ET, enzyme type.
† Includes bar A ($n = 22$), bar B ($n = 52$), and the three other bars sampled in 1992 ($n = 53$).

with likely recent patronage of 16 percent reported by controls and 8 percent by health center clients.

The community college case-patient yielded an ET2 organism and recalled patronizing bar A, during the 2 weeks prior to illness, only on the evening preceding symptoms. Excluding him from the case-control study did not materially alter the results. ET2 organisms were also recovered from a health center client and a bar B worker. The community college case occasionally patronized bar B as well as bar A. It is intriguing that the sole university case without recent exposure to bar A spent over 40 hours in bar B during the 2 weeks prior to onset.

Although our January 1993 carriage study was conducted well after the last case occurred, our basic findings do not depend on those data. The February 1992 survey took place within 1 month of the most recent of five monthly cases. This was 2 months before the last case and during the peak season for meningococcal disease. The May 1992 survey was completed within 2 weeks of the last case. Although 2 months had passed since immunization began, carriage subsequent to the immunization campaign showed no overall change after adjustment for confounders, nor was any difference seen between carriage among vaccinated and unvaccinated subjects. Meningococcal carriage duration averaged 9.6 months in one study (29), and almost 60 percent of 15- to 19-year-old carriers restudied after 17 weeks carried strains that were indistinguishable by monoclonal antibody tests from their initial strains (30). In light of these observations, there is no reason to believe that carriage of the outbreak strains during our surveys differed substantially from fall 1991 carriage.

If IMD was spread in bar A, as our data suggest, one or more chronic carriers may have played a role. Chronic carriage of meningococcus for up to 2 years has been documented (31, 32), although continuous carriage of a single strain for periods approaching the 15 months of this outbreak has not been confirmed. Another possibility is that workers, close associates, and some patrons formed a dynamic reservoir from which the organism was transmitted to susceptibles by shorter-term carriers. *N. meningitidis* might have been passed among workers and associates, or workers may have simply been sentinels of a "floating" colonization of the population exposed to bar A. It is also possible that organisms were transmitted outside of bar A by employees, customers, or other social contacts associated with bar A attendance, an issue we could not fully explore.

Several subsequent observations are generally supportive of our findings. Oropharyngeal carriage of *N. meningitidis* in the health center surveys was found to be elevated among students who had recently patronized campus bars, as compared with other students, and higher still among workers in these bars (33). Since the outbreak, five cases of meningococcal disease have been reported locally in adults through 1995. Four patients were of student age, among them a nonstudent bartender whose work site, though off-campus, was a generally crowded chain restaurant/bar heavily patronized by young adults. In addition, in October–December 1992, five nonfatal cases occurred among young adults in a university-oriented community in an adjacent state. The first two case-patients, recent college student visitors to the community we studied, yielded isolates that were indistinguishable by DNA fingerprinting from ET1. However, the remaining three cases were attributable to a different strain; they occurred in a nonstudent bartender and in one student patron and one nonstudent patron of the bar where he was employed (34).

Our study supports the results of other investigations (6, 30, 35) suggesting that colonization by epidemic clone(s) has been infrequent in recent serogroup C outbreaks. If the health center clients cultured are viewed as an essentially random sample of the roughly 34,000 university students with respect to carriage, then recovery of just two ET1 isolates suggests an ET1 carriage prevalence between 15 and 150 university students (80 percent binomial confidence interval) during the surveyed period.

Two cases have occurred in our college student population in the 46 months (through 1995) since the university's immunization program began in February 1992; one of these was in a community college student. In addition, a fall semester university student who had remained in the community without enrolling for the spring semester became ill. This experience contrasts with eight university students and one community college student becoming ill in the preceding 14 months. While outbreaks are often self-limiting and vaccine efficacy cannot be rigorously evaluated here, this experience is consistent with the hypothesis that immunization attenuated an outbreak that had previously persisted for over a year.

A very few carriers, under conditions conducive to transmission, may play a key role in generating disease and may contribute, directly or indirectly, to a substantial proportion of cases in an outbreak. Our data suggest that elevated levels of *N. meningitidis* carriage in campus bar workers, as well as the campus bar environment, may contribute to the spread of pathogenic strains. Thus, the relations of alcohol, cigarette smoke, and crowded bars to IMD outbreaks warrant further investigation.

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