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MENINGOCOCCAL DISEASE IN LOS ANGELES COUNTY, CALIFORNIA, AND AMONG MEN IN THE COUNTY JAILS

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ABSTRACT

Background From January through March 1993, there were 54 cases of meningococcal disease in Los Angeles County, California, of which 9 occurred among men incarcerated in the county's jail system, which was 40 percent above capacity at the time. Several of the 45 patients from the community had had contact with men recently released from a county jail.

Methods We interviewed patients from the community (n=42) and neighborhood controls matched with the patients for age, race, and ethnic group (n=84) about potential exposures. We collected and cultured pharyngeal swabs for *Neisseria meningitidis* from men entering the central jail (n=162), men leaving the central jail (n=379), members of the jail staff (n=121), and patients at a community health center (n=214). Meningococcal isolates were identified by serogrouping and multilocus enzyme electrophoresis.

Results The presence of community-acquired meningococcal disease was strongly associated with exposure to a person who had been in or worked at one of the county jails (multivariate matched odds ratio, 18.5; 95 percent confidence interval, 3.8 to 90.8; $P<0.001$). Pharyngeal carriage of meningococcus was significantly more frequent among men released from jail (19 percent) or entering jail (17 percent) than among workers at the jails (3 percent) or community residents seen at the clinic (1 percent). Among men entering jail, those who had previously been incarcerated were more often carriers than those who had not (21 percent vs. 7 percent, $P=0.03$). Of the isolates from nine community residents with serogroup C meningococcal disease, eight were the same strain as that isolated from the eight inmates with serogroup C disease.

Conclusions In this outbreak of meningococcal disease in Los Angeles County, nearly half of community residents with the disease had contact with persons who had been in a county jail. The high rates of carriage among recidivists and released inmates suggest that the men became meningococcal carriers while in jail. (N Engl J Med 1996;335:833-40.)

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INSTITUTIONALIZED populations may be affected disproportionately by outbreaks of certain respiratory infections.¹⁻⁹ Transmission to surrounding communities is frequently a matter of concern, although quantitative assessments of the risk in the community are rarely available. In 1986, 10 cases of meningococcal disease due to serogroup C organisms occurred among inmates of the Los Angeles County, California, Men's Jail System.¹⁰ The outbreak in the jails preceded a sharp increase in the incidence of meningococcal disease among county residents, which returned to normal levels over a three-year period.¹¹

Between January 1 and March 31, 1993, meningococcal disease developed in 54 persons living in Los Angeles County; 45 patients (83 percent) were community residents, 8 (15 percent) were inmates of the county jails, and 1 (2 percent) was a resident of a juvenile-detention facility when the illness began (Fig. 1). On follow-up of 12 community residents with disease, 8 reported that the illness began shortly after they had contact with a person recently released from jail. We conducted a case-control study among community residents and a study of pharyngeal carriage of *Neisseria meningitidis* among inmates, workers at the jail, and patients at a community health center in order to explore possible links between cases of community-acquired disease and the jail system.

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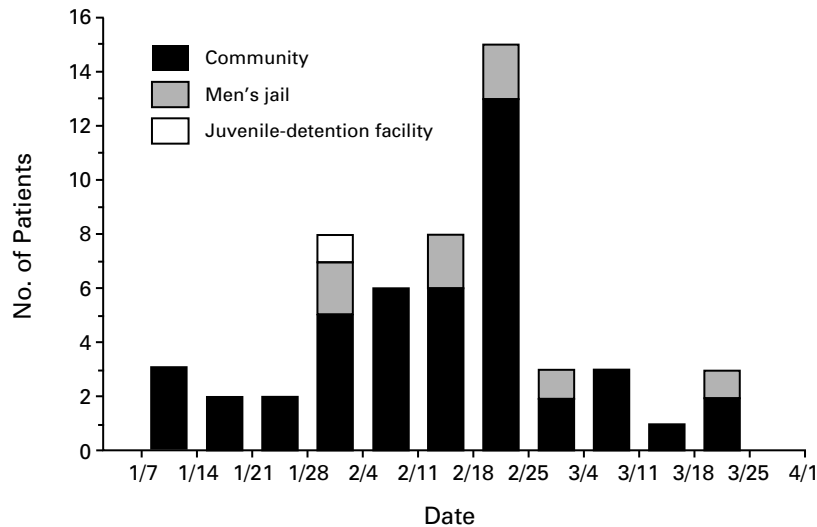


Figure 1. Meningococcal Disease in Los Angeles County, California, in January through March 1993. The solid sections of the bars indicate cases in community residents; the gray sections, cases in inmates of the Los Angeles County Men's Jail System; and the open section, a case in an inmate of the Los Angeles County Juvenile Hall Detention System. There were a total of 54 cases.

METHODS

Meningococcal Disease in Los Angeles County

We reviewed the medical records of all patients in the county who were reported to have meningococcal disease. A case of meningococcal disease was defined by isolation of *N. meningitidis* from a normally sterile site, by a positive latex-agglutination test for meningococcus in cerebrospinal fluid, or by hospitalization for an acute febrile illness with a purpuric rash. Cases were considered jail-associated if the illness began while the patient was incarcerated and community-associated if the patient was a resident of the community at the time of onset. The investigation was limited to cases occurring from January 1 through March 31, 1993.

Case-Control Study of Community-Acquired Disease

Of the 45 patients with meningococcal disease who were living in the community, 2 (4 percent) with serogroup C disease were excluded because they shared a household with another patient with disease; 1 additional subject declined to participate. Two neighborhood controls were identified for each remaining patient, matched according to age, race, and ethnic group.

Participants were asked about demographic characteristics, social activities, and environmental exposures. Study participants were also asked about "indirect exposure to the jail population," defined as contact with a person released from or employed by the Men's Jail System within three months before the onset of illness (for those with disease) or the date of the interview (for the controls). Adult household members answered questions about patients who were children or who had died.

After interviewing each patient in his or her home, the interview teams visited every third house in the same neighborhood until two appropriate controls were identified. Of 905 households visited, there was no answer at 400 (44 percent). Of the 505 remaining households, 364 (72 percent) had no eligible control. In the 141 remaining households, the eligible person was not available for interview in 26 (18 percent), and 31 (22 percent) declined to participate. Interviews were conducted with 42 patients with meningococcal disease and 84 controls from March 29 through April 2, 1993.

Characteristics of the Men's Jail System

In 1993, the Men's Jail System comprised nine facilities, and the California Board of Corrections rated the total capacity of the jails at 15,858 inmates. The average daily census during 1993 was 22,246, or 40 percent above capacity; the average duration of incarceration during the first 3 months of 1993 (32.1 days) was similar to that for the preceding 5-year period (31.2 days) (Clark JH, Los Angeles County Sheriff's Department: personal communication). Approximately 750 inmates entered or were released from one of the nine jails daily, all of whom passed through the Men's Central Jail (capacity, 6800 inmates).

Study of Pharyngeal Carriage

The point prevalence of meningococcal carriage was determined in consecutive, unrelated samples of newly incarcerated inmates ($n = 162$) and men being released from the jail ($n = 379$) and samples of workers at the jails ($n = 121$) and community residents more than 17 years of age who came to the County Health Center closest to the Men's Central Jail ($n = 214$). Subjects who agreed to participate were interviewed by means of structured questionnaires. Pharyngeal swabs were plated on Mueller-Hinton agar medium containing vancomycin, colistin, and nalidixic acid, placed immediately in lighted candle jars, and transferred to a carbon dioxide incubator. The survey was carried out at the Men's Central Jail on April 5 through 9, 1993, and at the health center on April 12 through 16, 1993.

Laboratory Characterization of Isolates

The serogroups and serotypes of *N. meningitidis* isolates were determined by multilocus enzyme electrophoresis with 24 enzymes.¹²⁻¹⁴ Electrophoretic types were determined by the mobility of constitutive enzymes; an index of genetic relatedness between strains was determined by weighting the degree of diversity at each of the 24 enzyme loci.^{12,15}

Statistical Analysis

In the case-control study, the Wilcoxon rank-sum test was used to compare the distributions of continuous variables. Multivari-

ate, stepwise, conditional logistic regression was performed with SAS software¹⁶ to assess confounding by variables that were statistically significant (alpha level = 0.05) in the univariate analysis. In the study of pharyngeal carriage in the county jails, unconditional logistic regression was performed with SAS software.¹⁶ P values were calculated with the two-tailed Fisher's exact test for analyses with small numbers of observations.

RESULTS

Epidemiologic Characteristics of the Outbreak in the County Jails

Between January 1 and March 31, 1993, meningococcal disease developed in eight persons who were incarcerated in the Los Angeles County Men's Jail System. All five with available isolates had serogroup C disease. One of the three with culture-negative disease had serogroup B meningococcus detected by latex-agglutination testing. Three additional jail-associated cases occurred in 1993; all isolates were determined to belong to serogroup C. The 11 inmates had been incarcerated a median of 24 days (range, 8 to 583) before the onset of illness.

Reviews of the men's records showed no evidence of direct contact among the jailed patients. However, two inmates in whom illness began in January 1993 were housed in the same 70-man dormitory. Another 2 inmates whose illness began in mid-February were housed at a different facility (in separate dormitories); on February 20, 1993, approximately 2000 inmates and workers at this facility received ciprofloxacin (750 mg) as chemoprophylaxis.

Rates of Meningococcal Disease in Los Angeles County

The incidence of meningococcal disease in the jail during the first three months of 1993 was 12.0 per 100,000 inmate-months (8 cases per 66,738 inmate-months); the incidence during January through March in earlier years was 0 per 100,000 inmate-months in 1990, 1.5 per 100,000 in 1991, and 3.0 per 100,000 in 1992.

During January through March 1993, the attack rate of meningococcal disease among residents of Los Angeles County was 0.61 per 100,000 population; cases were widely dispersed. Comparable attack rates during the same three-month period were 0.75 per 100,000 in 1990, 0.44 per 100,000 in 1991, and 0.46 per 100,000 in 1992.

Case-Control Study of Community-Acquired Disease

Among 42 community residents with meningococcal disease who were enrolled in the case-control study, 33 (79 percent) had disease confirmed by latex agglutination or culture (17 serogroup B, 14 serogroup C, and 2 serogroup W-135), and in 9 (21 percent) disease was diagnosed on clinical grounds. Three cases (7 percent) were fatal. As expected from the matching procedure, the patients with meningococcal disease were similar to the controls in age (median, 10 and 9 years, respectively), race (79 per-

cent vs. 81 percent white), and ethnic background (57 percent vs. 60 percent Hispanic); they were also similar in the percentage of subjects who were male (48 percent vs. 43 percent). The patients and controls did not differ significantly in terms of parental education level, income or type of governmental support, social or church activities, gang membership, alcohol consumption, frequency of visiting bars, illicit-drug use, recent antibiotic use, human immunodeficiency virus type 1 (HIV-1) infection, use of public transportation, or foreign travel.

In the univariate analysis, the households of the patients with meningococcal disease had more persons sharing the same bedroom than did the households of controls ($P=0.05$), and the patients were 3.1 times as likely as the controls to be exposed to second-hand tobacco smoke inside or outside the home ($P=0.006$). The patients were 16.1 times as likely as the controls to have had household contact with someone who had recently been released from one of the county jails or who was employed by the Men's Jail System ($P<0.001$). Indirect exposure to the jail population remained a risk factor after we excluded the patients whose initial interviews had led us to formulate the study hypothesis (matched odds ratio, 11.8; $P<0.001$).

Patients were more likely than controls to have had an upper respiratory tract infection (matched odds ratio, 3.2; 95 percent confidence interval, 1.4 to 7.1; $P=0.006$) or exposure to a household visitor with an upper respiratory tract infection (matched odds ratio, 2.6; 95 percent confidence interval, 1.02 to 6.6; $P=0.05$) in the two-week period preceding the onset of meningococcal disease.

In multivariate analysis, indirect exposure to the jail population remained strongly associated with disease ($P<0.001$) after we controlled for other factors (Table 1). We also evaluated risk factors for disease according to serogroup. Both the patients with serogroup B ($P=0.02$) and those with serogroup C ($P=0.02$) were significantly more likely than controls to have had indirect exposure to the jail population (Table 1). Neither a history of an upper respiratory tract infection nor exposure to a person with a recent upper respiratory tract infection was associated with meningococcal disease in the multivariate analysis.

Study of Pharyngeal Carriage

Men released from jail and those entering jail had a significantly higher prevalence of pharyngeal carriage of meningococcus than did jail staff members or community residents (Table 2). When analyzed according to serogroup, only carriage of *N. meningitidis* serogroup B was significantly more frequent among jailed subjects than in the other groups of subjects ($P<0.001$).

Among men entering the jail system, those with a

TABLE 1. MULTIVARIATE ANALYSIS OF RISK FACTORS ASSOCIATED WITH COMMUNITY-ACQUIRED MENINGOCOCCAL DISEASE IN LOS ANGELES COUNTY, JANUARY THROUGH MARCH 1993, ACCORDING TO SEROGROUP.

RISK FACTOR*	PATIENTS	CONTROLS	MATCHED ODDS RATIO (95% CI)†	P VALUE
All serogroups				
No. of subjects	42	84		
Indirect exposure to jail (%)	45	7	18.5 (3.8–90.8)	<0.001
Passive tobacco smoke (%)	62	36	2.9 (1.1–6.0)	0.04
No. of persons sharing bedroom	2.6	2.1	1.5 (0.9–2.2)	0.09
Serogroup B				
No. of subjects	17	34		
Indirect exposure to jail (%)	41	6	19.5 (1.7–122.7)	0.02
Passive tobacco smoke (%)	71	44	3.2 (0.7–16.8)	0.14
No. of persons sharing bedroom	2.6	2.2	1.5 (0.9–2.8)	0.16
Serogroup C				
No. of subjects	14	28		
Indirect exposure to jail (%)	57	11	13.4 (1.5–122.0)	0.02
Passive tobacco smoke (%)	57	36	2.2 (0.5–10.8)	0.32
No. of persons sharing bedroom	2.6	2.2	1.6 (0.7–3.9)	0.26

*Indirect exposure to jail denotes contact with a person released from or employed by the Los Angeles County Men's Jail System within three months before the onset of illness (for patients) or the date of the interview (for controls). Passive tobacco smoke includes exposure to second-hand smoke inside or outside the home. The mean number of persons who shared the same bedroom where the patient or control slept was analyzed as a continuous variable. The matched odds ratio indicates the risk associated with each additional person sharing the same bedroom.

†Odds ratios were determined by multivariate conditional logistic regression. CI denotes confidence interval.

TABLE 2. PHARYNGEAL CARRIAGE OF *N. MENINGITIDIS* IN APRIL 1993 AMONG INMATES OF THE CENTRAL JAIL AT THE TIME OF ENTRY OR RELEASE, AMONG JAIL WORKERS, AND AMONG PATIENTS AT A LOS ANGELES COUNTY HEALTH CENTER.

GROUP*	NO. TESTED	ALL SERO- GROUP†	SERO- GROUP B†	SERO- GROUP C
		no. of carriers (rate of carriage [%])		
Men released from jail	379	72 (19)	28 (7)	3 (1)
Men entering jail‡	162	27 (17)	21 (13)	0
With previous incarceration	114	24 (21)	19 (17)	0
For the first time	45	3 (7)	2 (4)	0
Jail workers	121	4 (3)	4 (3)	0
Community health center patients	214	2 (1)	1 (<1)	0

*Men released from and entering jail were nonoverlapping groups.

†Men released from or entering jail were significantly more likely to be carriers than jail staff members and community health center patients ($P < 0.001$ by the Mantel–Haenszel chi-square test). Men with a history of incarceration were more likely to be carriers than men entering jail for the first time ($P = 0.03$ by the Mantel–Haenszel chi-square test).

‡Data on whether three men entering jail had been previously incarcerated were missing.

history of incarceration were significantly more likely to be carriers of *N. meningitidis* than men being jailed for the first time (21 percent vs. 7 percent, $P = 0.03$) (Table 2). Only carriage of serogroup B meningococcus was significantly more frequent among previously jailed inmates than among men being incarcerated for the first time. Inmates with no previous exposure to the jail were more likely than patients at the community health center to be carriers of meningococcus (7 percent vs. 1 percent, $P = 0.04$ by the two-tailed Fisher's exact test).

Among men entering the jail system and those released from jail, white race and exposure to tobacco smoke (either active or passive) were significant risk factors for meningococcal carriage (Table 3). Among men entering jail, previous incarceration was an independent risk factor for carriage.

Laboratory Characterization of Isolates

Isolates from 14 of 17 community residents with serogroup B disease were available for enzyme typing; 12 electrophoretic types were identified. Only one patient who had been incarcerated had serogroup B disease, detected by latex agglutination, but no isolate was available in this case.

Isolates from 9 of 14 community residents with serogroup C disease were available. Eight were identical (electrophoretic type 24; genetic-relatedness

index, 100 percent). Isolates from the eight patients with jail-associated serogroup C disease were also electrophoretic type 24. This strain was closely related to the strain identified during the outbreak in the jail system in 1986 (electrophoretic type 22, which had identical mobility patterns for 22 of 24 enzymes).

Among the pharyngeal specimens obtained in the study of rates of carriage, serogroup B meningococcus was the predominant type that could be determined (Table 2). Twenty-six of 28 isolates of serogroup B meningococcus obtained from men released from jail were evaluated by electrophoretic typing. Nineteen of these isolates (73 percent) had unique patterns, and two separate clusters of five and two isolates each had identical patterns. Twenty of 21 serogroup B isolates obtained from men entering the jail system were evaluated by electrophoretic typing; 18 had distinct patterns, whereas 2 isolates were identical. All four serogroup B isolates from jail workers and the single serogroup B isolate from a patient at the community health center were unique on enzyme typing. Comparisons of serogroup B isolates among the four groups in which we studied carriage revealed only one common enzyme type, in a man released from jail and a newly jailed man who had been in jail before. One serogroup B isolate obtained from a carrier released from jail was identical on electrophoretic typing to the serogroup B strain isolated from a community patient with meningococcal disease.

Three pharyngeal isolates of serogroup C meningococcus with unique enzyme types were recovered,

all from men released from jail. One of these three isolates was electrophoretic type 24.

DISCUSSION

During the first three months of 1993, 45 percent of persons with sporadic meningococcal disease in Los Angeles County had been exposed to a person recently released from or employed by the county's Men's Jail System. Although a clonal outbreak of serogroup C meningococcal disease was occurring in the jail, both serogroup B and serogroup C meningococcal disease among community residents were epidemiologically linked with exposure to recently released inmates.

Meningococcal disease occurs after the transmission of a pathogenic strain by an asymptomatic or ill carrier of *N. meningitidis* to a susceptible host.^{17,18} Previously identified risk factors for meningococcal disease include intimate or household contact with a person with invasive meningococcal disease,^{19,20} household and institutional crowding,²¹⁻²³ upper respiratory tract infection,²⁴⁻³⁰ and active or passive exposure to tobacco smoke.^{22,23,31,32} We confirmed the significance of these risk factors, but we also identified a previously unrecognized risk factor for meningococcal disease. Household contact with a person recently exposed to the Men's Jail System in Los Angeles County was the strongest risk factor we identified, after adjustment for other factors. Surprisingly, indirect exposure to the jail population was the strongest risk factor for both serogroup B and serogroup C disease. Most community-acquired disease due to serogroup C meningococcus was caused by

TABLE 3. RISK FACTORS FOR PHARYNGEAL CARRIAGE OF *N. MENINGITIDIS* AMONG INMATES OF THE LOS ANGELES COUNTY MEN'S JAIL SYSTEM IN APRIL 1993.*

RISK FACTOR	ENTERING JAIL (N = 162)				P VALUE	RELEASED FROM JAIL (N = 379)			
	CARRIERS (N=27)	NONCARRIERS (N=135)	ODDS RATIO (95% CI)	%		CARRIERS (N=72)	NONCARRIERS (N=307)	ODDS RATIO (95% CI)	P VALUE
White race	89	61	5.2 (1.5-18.0)	0.01	86	66	3.3 (1.6-7.0)	<0.001	
Hispanic ethnic background	48	52	0.9 (0.4-2.1)	0.73	56	56	1.0 (0.6-1.7)	0.98	
Active tobacco smoking	82	56	3.4 (1.2-9.6)	0.02	68	53	1.9 (1.1-3.3)	0.02	
Exposure to tobacco smoke†	93	70	3.7 (0.8-16.6)	0.08	83	62	2.6 (1.2-5.4)	0.007	
Previous incarceration (≥1)	89	67	4.0 (1.1-14.0)	0.03	74	65	1.5 (0.8-2.7)	0.16	
Respiratory symptoms‡	41	36	1.2 (0.5-3.1)	0.66	49	39	1.5 (0.9-2.6)	0.13	
Antibiotic use§	11	18	0.6 (0.1-2.3)	0.40	15	13	1.2 (0.6-2.7)	0.57	
Household crowding¶	39	54	0.5 (0.2-1.4)	0.14	45	50	0.8 (0.5-1.4)	0.46	

*The odds ratios were derived by univariate analysis with unconditional logistic regression. CI denotes confidence interval.

†Exposure to tobacco smoke includes passive exposure to smoke at home or active tobacco smoking.

‡Respiratory symptoms denotes symptoms of a cold, sore throat, or influenza-like illness in the two weeks before culture.

§Antibiotic use denotes taking oral antibiotics in the four weeks before culture.

¶Household crowding indicates that the number of persons living in the household, divided by the number of rooms in the household, was greater than the median (0.80 for men entering jail [n = 153] and men released from jail [n = 369]).

the same strain identified in the outbreak in the county jails. In sharp contrast, serogroup B disease among community residents was caused by a variety of strains. For both patients with serogroup B disease and those with serogroup C disease, a history of upper respiratory tract infection did not account for the association between indirect exposure to the jail population and meningococcal disease.

We studied pharyngeal carriage to test the hypothesis that asymptomatic carriage of *N. meningitidis* by persons released from jail accounted for the increased risk of meningococcal disease among the contacts of such persons. The findings of our study were consistent with this hypothesis. Men who were being released from jail and those newly jailed who had previously been incarcerated were significantly more likely to be meningococcal carriers than were other subjects.

Although an outbreak of meningococcal disease of clonal serogroup C was occurring in the jail, pharyngeal carriage of serogroup C *N. meningitidis* was detected in fewer than 1 percent of men released from jail or returning to the jail. Recent studies of pharyngeal carriage during community outbreaks of clonal serogroup C disease have repeatedly demonstrated low rates of carriage of the implicated pathogenic strain.^{10,21,32-35} These findings suggest a plausible link between the jail system and serogroup C meningococcal disease in the community — namely, the transmission of a more virulent but rarely carried strain of *N. meningitidis* from the jail to the community by asymptomatic carriers released from jail.

Our investigation also provides a clear explanation for the epidemiologic link between men released from jail and serogroup B meningococcal disease in the community: the person-to-person transmission of meningococcus by asymptomatic carriers released from jail to community residents. The higher prevalence of meningococcal carriage among jailed inmates than among community residents, and among men previously incarcerated than among those being jailed for the first time, strongly suggests that asymptomatic carriage of meningococcus (particularly of serogroup B strains) was acquired in jail. Asymptomatic carriage can persist for long periods. Greenfield et al. found the median duration of meningococcal carriage to be 9.6 months during a non-epidemic period.³⁶

It is not surprising that the high rate of carriage of serogroup B meningococcus among jail inmates was not accompanied by increased rates of serogroup B meningococcal disease in the Men's Jail System. The development of active disease is related to preexisting immunity as well as to exposure to pathogenic strains.³⁷ In our study, the high rates of meningococcal carriage among men jailed more than once (21 percent) and the high proportion of inmates with a history of recidivism (72 percent)

suggest that the majority of inmates may have had preexisting immunity to most strains of *N. meningitidis*. However, high rates of asymptomatic serogroup B carriage among men released from jail may have been responsible for the transmission of these strains to community residents who lacked preexisting immunity.

Previously identified risk factors for meningococcal carriage include living in a household with a person with meningococcal disease or a carrier,^{17,36,38} an age from 15 to 24 years,^{26,33,39-42} white race,^{21,33} male sex,^{29,39} household or institutional crowding,^{10,34,43,44} active and passive exposure to tobacco smoke,^{39,45,46} and a recent history of upper respiratory tract infection.^{26,27} In our study, high rates of carriage among men released from jail and those returning to jail suggest that the jail itself, rather than the community from which the men came, played a dominant part in producing meningococcal carriage among incarcerated men. On the basis of the California Board of Correction's recommended inmate population for the Men's Jail System, the daily capacity of the jail was exceeded by 40 percent in 1993. Thus, crowding and prolonged or repeated exposure to the county jails are the most likely explanations of the increase in meningococcal disease and carriage among jail inmates. Differences in rates of carriage between released inmates and jail workers may be due to distance maintained between staff and inmates by physical barriers.

The 1993 Los Angeles serogroup C clone was also responsible for outbreaks of meningococcal disease in several other North American communities in recent years.^{21,47} The slight variation between the 1993 and 1986 Los Angeles County strains is consistent with the natural divergence of a clonal complex over time.^{13,48} Although only 3 of the 14 serogroup B meningococcal isolates we obtained from community residents were clonal, the recent emergence of a highly virulent strain of serogroup B *N. meningitidis* (electrophoretic type 5) in Oregon and Washington State^{49,50} highlights the importance of determining the serogroups of all meningococcal isolates. The introduction of a virulent serogroup B clone into the jail could increase the risk of serogroup B disease among inmates and community residents who have contact with men released from jail.

The principal findings of our investigation are subject to certain limitations. Selection bias in the identification of matched neighborhood controls could have influenced our results. However, because 45 percent of the patients with community-acquired disease reported household contact with a released inmate or jail employee, we believe that only the magnitude of this association, rather than the association itself, may have been influenced by selection bias.

Current recommendations for the prevention of meningococcal disease include antibiotic chemopro-

phylaxis for contacts of persons with invasive disease in specific high-risk settings, such as households and day-care centers,⁵¹ and vaccination of a targeted population at increased risk during an outbreak of vaccine-preventable meningococcal disease.^{21,51} In 1993, control measures were difficult to implement. Despite routine chemoprophylaxis for close contacts of jailed patients, new cases occurred in the jail. More widespread chemoprophylaxis was not practical because of problems with administering the drug on a mass basis and the potential for drug resistance. Immunization was also hampered by the size and turnover of the jail population, as well as by the lack of identification of any clear subgroup at increased risk. Furthermore, immunization of inmates would have had no effect on disease in the community, because the available meningococcal vaccine has little effect on nasopharyngeal carriage.

Communicable diseases are an important public health problem within correctional facilities in the United States, as several well-documented outbreaks attest.^{1-9,52} Because inmates are generally poor and undereducated, medical care may be unavailable in their home communities.⁵² Our study highlights the importance of reducing overcrowding in jails and improving comprehensive primary care and prevention services for inmates. Between 1980 and 1990, the average daily population of prisons and jails in the United States more than doubled.⁵² The failure to adopt a more comprehensive public health approach in correctional facilities poses increasing risks to the health of both inmates and the communities to which they return.

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REFERENCES

- King L, Geis G. Tuberculosis transmission in a large urban jail. *JAMA* 1977;237:791-2.
- Stead WW. Undetected tuberculosis in prison: source of infection for community at large. *JAMA* 1978;240:2544-7.
- Valway SE, Greifinger RB, Papania M, et al. Multidrug-resistant tuberculosis in the New York State prison system, 1990-1991. *J Infect Dis* 1994;170:151-6.
- Transmission of multidrug-resistant tuberculosis among immunocompromised persons in a correctional system — New York, 1991. *MMWR Morb Mortal Wkly Rep* 1992;41:507-9.
- Tuberculosis transmission in a state correctional institution — California, 1990-1991. *MMWR Morb Mortal Wkly Rep* 1992;41:927-9.
- Hospedales CJ, Johnson D, Hall W, Stobierski M, Hutchinson C, Dietrich S. Outbreak of Legionnaires' disease associated with a cooling tower at a state prison, Michigan. In: *Epidemic Intelligence Service: 43rd annual conference*. Atlanta: Centers for Disease Control and Prevention, 1994.
- Hoge CW, Reichler MR, Dominguez EA, et al. An epidemic of pneumococcal disease in an overcrowded, inadequately ventilated jail. *N Engl J Med* 1994;331:643-8.
- Rubella outbreaks in prisons — New York City, West Virginia, California. *MMWR Morb Mortal Wkly Rep* 1989;34:615-8.
- Varicella outbreak in a women's prison — Kentucky. *MMWR Morb Mortal Wkly Rep* 1989;38:635-6, 641-2.
- Thomas JC, Bendana NS, Waterman SH, et al. Risk factors for carriage of meningococcus in the Los Angeles County men's jail system. *Am J Epidemiol* 1991;133:286-95.
- Thomas JC, Bendana NS, Waterman SH. Meningococcal disease in Los Angeles County, 1981 through 1990. *Am J Public Health* 1993;83:1790-1.
- Caugant DA, Mocca LF, Frasch CE, Froholm LO, Zollinger WD, Selander RK. Genetic structure of *Neisseria meningitidis* populations in relation to serogroup, serotype, and outer membrane protein pattern. *J Bacteriol* 1987;169:2781-92.
- Woods TC, Helsel LO, Swaminathan B, et al. Characterization of *Neisseria meningitidis* serogroup C by multilocus enzyme electrophoresis and ribosomal DNA restriction profiles (ribotyping). *J Clin Microbiol* 1992;30:132-7.
- Selander RK, Caugant DA, Ochman H, Musser JM, Gilmour MN, Whittam TS. Methods of multilocus enzyme electrophoresis for bacterial population genetics and systematics. *Appl Environ Microbiol* 1986;51:873-84.
- Jacobs D. SAS/GRAPH software and numerical taxonomy. In: *Proceedings of 15th Annual SAS Users Group Conference*, Nashville, April 1-4, 1990. Cary, N.C.: SAS Institute, 1990:1413-8.
- Microsoft Windows environment: changes and enhancements to the SAS system, release 6.10. Cary, N.C.: SAS Institute, 1994.
- Broome CV. The carrier state: *Neisseria meningitidis*. *J Antimicrob Chemother* 1986;18:Suppl A:25-34.
- Schwartz B. Chemoprophylaxis for bacterial infections: principles of and application to meningococcal infections. *Rev Infect Dis* 1991;13:Suppl 2:S170-S173.
- Meningococcal Disease Study Group. Meningococcal disease: secondary attack rate and chemoprophylaxis in the United States, 1974. *JAMA* 1976;235:261-5.
- De Wals P, Hertoghe L, Borlee-Grimee I, et al. Meningococcal disease in Belgium: secondary attack rate among household, day-care nursery and pre-elementary school contacts. *J Infect* 1981;3:Suppl:53-61.
- Jackson LA, Schuchat A, Reeves MW, Wenger JD. Serogroup C meningococcal outbreaks in the United States: an emerging threat. *JAMA* 1995;273:383-9.
- Stanwell-Smith RE, Stuart JM, Hughes AO, Robinson P, Griffin MB, Cartwright K. Smoking, the environment and meningococcal disease: a case control study. *Epidemiol Infect* 1994;112:315-28.
- Stuart JM, Cartwright KAV, Dawson JA, Rickard J, Noah ND. Risk factors for meningococcal disease: a case control study in south west England. *Community Med* 1988;10:139-46.
- Jones DM, Kaczmarek EB. Meningococcal infections in England and Wales: 1993. *Commun Dis Rep CDR Rev* 1994;4(9):R97-R100.
- Harrison LH, Armstrong CW, Jenkins SR, et al. A cluster of meningococcal disease on a school bus following epidemic influenza. *Arch Intern Med* 1991;151:1005-9.
- Cartwright KA, Jones DM, Smith AJ, Stuart JM, Kaczmarek EB, Palmer SR. Influenza A and meningococcal disease. *Lancet* 1991;338:554-7.
- Moore PS, Hierholzer J, DeWitt W, et al. Respiratory viruses and mycoplasma as cofactors for epidemic group A meningococcal meningitis. *JAMA* 1990;264:1271-5.
- Morrow HW, Slaten DD, Reingold AL, Werner SB, Fenstersheib MD. Risk factors associated with a school-related outbreak of serogroup C meningococcal disease. *Pediatr Infect Dis J* 1990;9:394-8.
- Krasinski K, Nelson JD, Butler S, Luby JP, Kusmiesz H. Possible association of mycoplasma and viral respiratory infections with bacterial meningitis. *Am J Epidemiol* 1987;125:499-508.
- Young LS, LaForce FM, Head JJ, Feeley JC, Bennett JV. A simultaneous outbreak of meningococcal and influenza infections. *N Engl J Med* 1972;287:5-9.
- Haneberg B, Tønnum T, Rodahl K, Gedde-Dahl TW. Factors preceding the onset of meningococcal disease, with special emphasis on passive smoking, stressful events, physical fitness and general symptoms of ill health. *NIPH Ann* 1983;6:169-73.
- Imrey PB, Jackson LA, Ludwinski PH, et al. Outbreak of serogroup C meningococcal disease associated with campus bar patronage. *Am J Epidemiol* 1996;143:624-30.
- Idem*. Meningococcal carriage, alcohol consumption, and campus bar patronage in a serogroup C meningococcal disease outbreak. *J Clin Microbiol* 1995;33:3133-7.
- Le Saux N, Ashton F, Rahman M, et al. Carriage of *Neisseria* species in communities with different rates of meningococcal disease. *Can J Infect Dis* 1992;3:60-4.
- Mitchell LA, Ochnio JJ, Glover C, Lee AY, Ho MK-L, Bell A. Analysis of meningococcal serogroup C-specific antibody levels in British Columbian children and adolescents. *J Infect Dis* 1996;173:1009-13.
- Greenfield S, Sheeche PR, Feldman HA. Meningococcal carriage in a population of "normal" families. *J Infect Dis* 1971;123:67-73.
- Goldschneider I, Gotschlich EC, Artenstein MS. Human immunity to

- the meningococcus. I. The role of humoral antibodies. *J Exp Med* 1969; 129:1307-26.
38. Munford RS, Taunay AE, de Morais JS, Fraser DW, Feldman RA. Spread of meningococcal infection within households. *Lancet* 1974;1:1275-8.
39. Caugant DA, Høiby EA, Magnus P, et al. Asymptomatic carriage of *Neisseria meningitidis* in a randomly sampled population. *J Clin Microbiol* 1994;32:323-30.
40. Olsen SF, Djurhuus B, Rasmussen K, et al. Pharyngeal carriage of *Neisseria meningitidis* and *Neisseria lactamica* in households with infants within areas with high and low incidences of meningococcal disease. *Epidemiol Infect* 1991;106:445-57.
41. Gold R, Goldschneider I, Lepow ML, Draper TF, Randolph M. Carriage of *Neisseria meningitidis* and *Neisseria lactamica* in infants and children. *J Infect Dis* 1978;137:112-21.
42. Marks MI, Frasch CE, Shapera RM. Meningococcal colonization and infection in children and their household contacts. *Am J Epidemiol* 1979; 109:563-71.
43. Aycock WL, Mueller JH. Meningococcus carrier rates and meningitis incidence. *Bacteriol Rev* 1950;14:115-60.
44. Fraser PK, Bailey GK, Abbott JD, Gill JB, Walker DJ. The meningococcal carrier-rate. *Lancet* 1973;1:1235-7.
45. Kremastinou J, Blackwell C, Tzanakaki G, Kallergi C, Elton R, Weir D. Parental smoking and carriage of *Neisseria meningitidis* among Greek schoolchildren. *Scand J Infect Dis* 1994;26:719-23.
46. Stuart JM, Cartwright KAV, Robinson PM, Noah ND. Effect of smoking on meningococcal carriage. *Lancet* 1989;2:723-5.
47. Whalen CM, Hockin JC, Ryan A, Ashton F. The changing epidemiology of invasive meningococcal disease in Canada, 1985 through 1992: emergence of a virulent clone of *Neisseria meningitidis*. *JAMA* 1995;273:390-4.
48. Scholten RJPM, Poolman JT, Valkenburg HA, Bijlmer HA, Dankert J, Caugant DA. Phenotypic and genotypic changes in a new clone complex of *Neisseria meningitidis* causing disease in the Netherlands, 1958-1990. *J Infect Dis* 1994;169:673-6.
49. Serogroup B meningococcal disease — Oregon, 1994. *MMWR Morb Mortal Wkly Rep* 1995;44:121-4.
50. Reeves MW, Perkins BA, Diermayer M, Wenger JD. Epidemic-associated *Neisseria meningitidis* detected by multilocus enzyme electrophoresis. *Emerging Infect Dis* 1995;1:53-4.
51. Meningococcal vaccines. *MMWR Morb Mortal Wkly Rep* 1985;34: 255-9.
52. Glaser JB, Greifinger RB. Correctional health care: a public health opportunity. *Ann Intern Med* 1993;118:139-45.