Risk of Meningococcal Infection in College Students

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Neisseria meningitidis is a major cause of bacterial meningitis and other invasive infections in the United States. In the past few years, there have been an increasing number of meningococcal infection outbreaks, including on college campuses. Most of these have been caused by serogroup C N. meningitidis, which is potentially vaccine preventable with the currently available tetravalent meningococcal polysaccharide vaccine. Recently, the American College Health Association issued a statement recommending that college students consider meningococcal immunization to reduce the risk of infection. Neither the Advisory Committee on Immunization Practices nor the American Academy of Pediatrics has issued a recommendation for college students. No published studies are available that document the incidence of meningococcal infection in college students. No published studies have documented the incidence of meningococcal infection in college students or whether the incidence is higher than in the general population of the same age.

Objective To compare the incidence of invasive meningococcal infection in college students with that of the general population of the same age.

Setting and Patients Maryland residents with meningococcal infection from 1992-1997 identified from active, laboratory-based, statewide surveillance for invasive meningococcal disease.

Main Outcome Measures Incidence of invasive meningococcal infection.

Results Of 228 patients with invasive meningococcal infection, 67 were aged 16 to 30 years; 11 and 3 of these attended Maryland 4- and 2-year colleges, respectively. Of these, 12 (86%) had infection caused by Neisseria meningitidis serogroups included in the current meningococcal vaccine. The average annual incidence was 1.74 per 100 000 among students in 4-year schools vs 1.44 per 100 000 for the general population of the same age (P = .60). Among students in 4-year schools, the incidence was 3.24 per 100 000 in on-campus residents vs 0.96 per 100 000 in off-campus residents (relative risk, 3.4; 95% confidence interval, 1.0-11.6; P = .05).

Conclusions The incidence of meningococcal infection in college students is similar to the incidence in the general population of the same age, but college students residing on campus appear to be at higher risk than those residing off campus.

METHODS Surveillance for Invasive Meningococcal Infection
Active surveillance for invasive meningococcal infection was initiated in Maryland on November 1, 1991, as part of the Maryland Bacterial Invasive Disease Surveillance project, which is a component of the Emerging Infections Program Network that is coordinated by the Centers for Disease Control and Prevention, Atlanta, Ga. The surveillance case definition is the isolation of N. meningitidis from a normally sterile body fluid, such as blood or cerebrospinal fluid, from a Maryland resident of any age. Patients with disease onset between January 1, 1992, and December 31, 1997, were included in the study.

Context The number of meningococcal outbreaks on college campuses have been increasing in the past few years. However, no published studies have documented the incidence of invasive meningococcal infection in college students or whether the incidence is higher than in the general population of the same age.

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cluded in the study. All acute care hospitals in Maryland participate, as do major hospitals in Washington, DC, at which southern Maryland residents frequently seek medical care. Nonhospital microbiology laboratories that process blood cultures are also included. For each eligible case, the hospital infection control professional completes a 1-page case report form, which includes demographic and brief clinical information, and the laboratory submits the bacterial isolate for species confirmation and further testing. Staff members from the Maryland Bacterial Invasive Disease Surveillance project make biweekly telephone calls to hospital infection control practitioners to ascertain cases not reported spontaneously. Microbiology laboratory audits to identify unreported cases are performed twice yearly by reviewing the laboratory records. In July 1998, a letter was sent to the director of student health at each of the 21 American College Health Association member colleges in Maryland to determine whether there were meningococcal cases among students in these schools from 1992 through 1997 that had not been reported.

**Denominator Data for the Calculation of Rates**

A variety of sources was used to determine the population denominators for 2-year and 4-year colleges in Maryland, 4-year college students residing on campus, and the noncollege population 18 to 22 years old. Lists of Maryland colleges were obtained from the 1998 edition of Peterson’s Guide to Colleges in the Middle Atlantic States (Peterson’s, Princeton, NJ, 1997) and the Maryland Higher Education Commission. Enrollment data are for the fall of 1997 and are from the database maintained by the Maryland Higher Education Commission, except for 1 military school, for which enrollment data were obtained by telephone. Two small religious colleges were excluded from the denominator data due to the absence of enrollment data in Peterson’s guides and failure to provide the requested information. A correspondence school whose students mainly study abroad was also excluded.

Housing information for fall 1997 or spring 1998 was determined by telephone inquiry to each school’s office of housing, residence life, or student affairs. Information was requested about the number of students living in on-campus housing either at the beginning of the school year or, if that was not available, the current number. On-campus housing was defined as a dormitory or apartment located on the college campus, and off-campus housing was defined as a dwelling located elsewhere, including a sorority or fraternity.

Denominator data for the number of all Maryland residents 18 to 22 years old were estimates for 1995 based on the 1990 census. The general population was defined as the number of Maryland residents 18 to 22 years old minus the Maryland 4-year college student population. The incidence of meningococcal infection in 4-year college students was compared with the incidence in the general population 18 to 22 years old, which included 2-year college students (and excluded 4-year college students), for several reasons. College outbreaks have tended to occur among students attending universities, rather than community colleges. Furthermore, the living arrangements of students attending community colleges tend to be more similar to the general population because dormitories are uncommon in this setting. Finally, the rapid attrition among 2-year college students makes it difficult to accurately establish separate denominators for the 2-year college and noncollege populations. As an example, the first-year enrollment in Maryland 2-year colleges was 75,747 in 1997–1998 vs 27,080 for second-year enrollment; enrollment figures for 4-year schools were much more stable.

**Statistical Analysis**

Epi Info version 6 (Centers for Disease Control and Prevention, October 1997) was used for the analyses. The Fisher exact and Kruskal-Wallis tests were used for the analysis of dichotomous and continuous variables, respectively.

**RESULTS**

A total of 228 meningococcal cases of all ages were identified through surveillance from January 1, 1992, through December 31, 1997, for an average annual incidence of 0.8 per 100,000 population. A response was obtained from each of the directors of student health of the 21 American College Health Association member schools and no additional cases were identified.

The incidence was highest in children younger than 5 years and was generally under 1 per 100,000 population in persons at least 5 years old (Figure 1). However, there was a substantial peak in the 15- to 24-year-old age group that was mostly due to relatively high incidence among individuals 16 to 19 years old and, most notably, among individuals 17 years old.

Of the 228 patients, 67 were 16 to 30 years old. Eleven attended a 4-year college at the time of illness onset, 3 attended a 2-year college, 3 attended non-Maryland colleges, 2 attended technical schools, 17 attended high school, and...
Among the fatal cases, 1 was serogroup B, 2 were C, and 1 was Y.

There were 2 cases in 1992; 1 each in 1993, 1994, and 1996; 4 cases in 1995; and 5 cases in 1997. Four 4-year colleges had more than 1 case during the study period. In the 1 college with 3 cases, 1 case occurred in 1995 and 2 serogroup C cases occurred 5 weeks apart in 1997. An additional 3 colleges each had 2 cases that were not considered to be epidemiologically related because they either occurred in a different year or were of different serogroups. There were 5 colleges each with 1 case. Seven case patients, all students attending 4-year colleges, resided in dormitories or other on-campus housing; none of the case patients lived in fraternity or sorority housing. The mean total number of persons sleeping in the same bedroom as the case patient (including the case patient) was 2 for those residing in on-campus housing and 1 for those residing off campus ($P < .01$).

The annual incidence among undergraduates in 4-year colleges was 1.74 per 100 000 population vs 1.44 for the general population 18 to 22 years old ($P = .60$) (TABLE). Among 4-year school undergraduates, the incidence was 3.24 in on-campus residents, significantly higher than the incidence of 0.96 in off-campus residents (relative risk, 3.4; 95% confidence interval, 1.0-11.6; $P = .05$). The comparison of incidence between on-campus residents and the general population had a $P$ value of .08. The class-specific incidence for 4-year undergraduates was 1.7, 3.0, 0.7, and 1.7 per 100 000 population for freshmen, sophomores, juniors, and seniors, respectively. The seasonality for all 4-year undergraduate cases is shown in Figure 2.

**COMMENT**

In this study we demonstrated that Maryland 4-year college students did not have an incidence of invasive meningococcal infection that was substantially higher than the general population 18 to 22 years old. Our results are in general agreement with a recent study in which it was estimated that the annual incidence of meningococcal infection in college students could not be higher than 1.3 per 100 000 students. The lack of case clustering during the first few months of the academic year and the lack of a higher incidence in college freshmen suggests that the college setting is not fully analogous to the military, possibly because the degree of crowding in college housing is less than in military barracks. However, a recent study in the United Kingdom suggests a higher incidence of meningococcal infection in university undergraduates than in the general population, indicating that there may be geographic variability in the risk of meningococcal infection in college students.

Among students attending 4-year schools, the incidence of meningococcal infection was more than 3-fold higher in on-campus residents than in students who lived off campus, a phenomenon that has been previously observed. Although it is possible that the increased risk of meningococcal infection was in part a result of the relative crowding typically associated with living in a dormitory, on-campus residence could also be a marker for other risk factors recently associated with college students, including alcohol-related behaviors and exposure to tobacco smoke.

Our study does not allow us to directly assess whether the incidence of meningococcal infection in college students is increased.
MENINGOCOCCAL INFECTION IN COLLEGE STUDENTS

Figure 2. Month of Onset of Meningococcal Infections, Maryland 4-Year College Students, 1992-1997

<table>
<thead>
<tr>
<th>Month</th>
<th>No. of Cases</th>
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<td>Jan</td>
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<td>Feb</td>
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meningococcal infection in college students has increased concomitantly with the increase in outbreaks. However, there is substantial evidence for an overall increase in meningococcal disease in late adolescence in the United States. The incidence of invasive meningococcal infection in persons 15 to 19 years old in selected areas of the country in 1989 through 1991 was low with no peak in the incidence.13 However, a recent analysis of active surveillance data from 1992 through 1996 demonstrated the emergence of a dramatic peak in persons 15 to 19 years old, similar to what we observed in Maryland (N. A. Rosenstein, MD, written communication, March 5, 1999). This shift toward disease in older children and young adults has been described in the outbreak setting and, despite numerous hypotheses, has not been adequately explained.16,17

What are the implications of this study for meningococcal immunization policy? From a public health perspective, it may be difficult to justify a national immunization policy focusing on college students. The incidence in college students does not appear to be substantially higher than that in the general population of the same age and, in fact, appeared to be lower than in children 17 years old, the vast majority of whom were high school students. Furthermore, the public health impact of such a program would most likely not be major. In this study, only 6% of Maryland cases occurred among college students. A high vaccine coverage in young, generally healthy adults can be difficult to achieve.18 Importantly, the currently available tetravalent purified polysaccharide vaccine has a negligible effect on nasopharyngeal carriage of N meningitidis, indicating that this vaccine would not offer herd immunity.19 The available vaccine also does not cover serogroup B.

On the other hand, there are factors in favor of immunizing college students. Meningococcal infection is a devastating illness that occurs in the prime of life and frequently is fatal.1,20 Most infections are preventable with a vaccine that is safe and efficacious, and an increasing proportion of isolates causing invasive infection are included in the vaccine.2,21 In some college settings, high meningococcal vaccine coverage rates have been achieved.22 More than 80% of our cases among college students for whom we had serogroup information potentially could have been prevented with the currently available meningococcal vaccine, as could 3 of the 4 fatal cases.23 From an individual standpoint, the vaccine is inexpensive relative to the cost of higher education. Although immunization in response to outbreaks on college campuses is warranted, it is relatively ineffective in aborting many institutional outbreaks. This is because cases in institutional outbreaks tend to cluster over a short period of time, such that a large proportion of cases often occur before an immunization campaign can be initiated.2,17 In contrast, the routine immunization of incoming college freshman could potentially prevent outbreaks and sporadic disease in college students, as well as prevent the phenomenal disruption that occurs on college campuses as a result of meningococcal outbreaks.23 Finally, while the incidence in Maryland college students was not higher than in the general population, on-campus residents were at higher risk than those living off campus. Taken together, we believe that it is reasonable for physicians to provide college students, especially those living on campus, with meningococcal vaccine.

This study underscores the value of continuous active, population- and laboratory-based surveillance to monitor the evolving epidemiology of meningococcal disease. This study is limited by the small number of cases, so additional studies are needed to confirm the results. The high meningococcal incidence in high school students also deserves further investigation. Additional studies also are needed to better define risk factors for invasive meningococcal infection among high school and college students. These data will be crucial for developing a cogent national vaccine policy when new and more effective vaccines become available for N meningitidis.

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REFERENCES


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To him who devotes his life to science, nothing can give more happiness than increasing the number of discoveries, but his cup of joy is full when the results of his studies immediately find practical applications.
—Louis Pasteur (1822-1895)
Alaskan Natives, and Native Hawaiians. Many objects, such as full head masks, have already been returned. However, concerns have arisen about risk of exposure to museum-applied pesticides (e.g., arsenic, mercury, organophosphates, car-bamates, organochlorines, and volatiles).

We evaluated 3 ceremonial objects repatriated under NAGPRA. The tribe’s cultural preservation office requested that we neither describe the objects nor provide details of their cultural use. To our knowledge, this is the first report of a chemical analysis of repatriated artifacts.

**Methods.** Three objects were analyzed. Each was made of leather, with attached grasses, corn husks, feathers, horsehair, yarn, and paint. Associated museum catalog records were reviewed for evidence of pesticide use.

Samples were taken of adherent debris and representative surface material. Metal content, including arsenic, was measured by energy-dispersive x-ray analysis. Total object arsenic levels were estimated by weighted sample averaging applied to the total surface area. Organic pesticide residue was determined by in-line pyrolysis gas chromatography–mass spectroscopy (GC-MS). Volatiles were analyzed by GC-MS of 4-hour ambient-temperature air samples from a Mylar bag enclosing the object.

**Results.** There was no visible evidence of contamination on any object. Object 1 had arsenic on all surfaces, with the highest concentrations around eye holes, surface paint, and feathers. Total object arsenic level was 1.3 g. Catalog records confirmed that the object had been treated with sodium arsenite. Object 2 had trace amounts of naphthalene on interior surfaces, but none was detected in head-space air. There were no records of pesticide treatment. Object 3 had moderate amounts of arsenic on exterior surface paint. Total object arsenic level was 60 mg. There were no records of pesticide treatment.

**Comment.** Museums apply pesticides to preserve perishable objects, and arsenic was widely used as a museum pesticide from the 1800s through the 1970s. Objects 2 and 3, containing naphthalene and arsenic, respectively, had no documentation of pesticide treatment. Thus, museum documentation cannot be relied on to identify contaminated specimens.

Arsenic on these objects poses a potential health threat. Daily ingestion of as little as 3 to 4 mg can result in long-term toxicity, and an acute ingestion of 1 to 3 mg/kg may be lethal. The greatest acute danger would be to a young child who chewed on a significantly contaminated object. Long-term exposure may occur via dust in storage and usage areas, from food stored with ceremonial objects, or during ceremonial use in which objects are handled or worn.

Nationwide, hundreds of thousands of artifacts are subject to repatriation, including more than 400 similar objects to this tribe. Wipe sampling of similar objects in museums has demonstrated the presence of arsenic and mercury (Leigh Kuwanwisiwma, written communication, 1999), and other museum items carry residues of arsenic, mercury, DDT, and strychnine. Our preliminary results suggest that all museum objects subject to repatriation should be tested for pesticide residues.

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**CORRECTIONS**


Error in Table Footnote: In the Original Contribution entitled “Risk of Meningococcal Infection in College Students” published in the May 26, 1999, issue of THE JOURNAL (1999;281:1906-1910), there was incorrect wording in the table footnote. On page 1908, the second footnote to the Table should read “Aged 18 to 22 years, excluding the 4-year college population (see “Methods” section).”