
Acquisition of *Pseudomonas cepacia* at summer camps for patients with cystic fibrosis

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To assess the risk of acquisition of *Pseudomonas cepacia* by person-to-person transmission at cystic fibrosis summer camps, we conducted in 1990 a study at three camps attended by patients with cystic fibrosis who had *P. cepacia* infection and patients without *P. cepacia* infection but who were considered susceptible to infection. We obtained sputum or throat cultures from campers on their arrival at, weekly during, at the end of, and 14 to 30 days after camp. We compared the incidence of sputum conversion of patients at camp with that of patients outside camp by culturing specimens from noncamper control subjects with cystic fibrosis who were known not to be infected ≤ 2 weeks before and 4 to 6 weeks after camp. We also determined the risk factors for *P. cepacia* acquisition by determining the relative risk of acquisition between campers who were exposed versus campers who were not exposed to campers known to be infected or to potential environmental sources of *P. cepacia* at camp. The ribotype of *P. cepacia* isolates from campers with sputum conversion was compared with that of isolates from other campers and from an environmental source. The cumulative incidence of sputum conversion during the study period was 6.1% (11/181) among campers compared with no incidence (0/92) among noncampers ($p = 0.02$, Fisher Exact Test). The incidence of sputum conversion at camp varied according to the prevalence of campers with known infection ($p < 0.001$, chi-square test for trend). The rate of sputum conversion was higher in the camp with longer duration (relative risk = 12.0; 95% confidence interval = 2.7 to 53.5). Ribotyping showed that *P. cepacia* isolates from all 11 campers with sputum conversion were identical or similar (1 to 2 band difference) to isolates of other *P. cepacia*-infected campers including co-converters. These results suggest that *P. cepacia* can be acquired by patients with cystic fibrosis who are attending summer camp for such patients, possibly through person-to-person transmission, and that the risk increases with the prevalence of *P. cepacia*-infected campers and the duration of camp. (J PEDIATR 1994;124:694-702)

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Pseudomonas cepacia, a multi-drug-resistant gram-negative bacillus, has been associated with chronic colonization of the respiratory tract of patients with cystic fibrosis, and in some patients has been associated with rapid decline in pulmonary function, increased hospitalization, and earlier death.¹⁻⁶ In 1990 *P. cepacia* was isolated from 3.2% of all patients' cultures from a national registry of patients with CF,⁷ and the incidence of new acquisition of *P. cepacia* has been estimated to be 1.5% per year (S. FitzSimmons: personal communication, 1992). Studies suggest that person-to-person transmission of *P. cepacia* is one possible mode of acquisition in and outside the hospital setting; however, the risk of acquiring *P. cepacia* at CF summer camps by a patient with CF has not been carefully studied.^{2, 8-11} Because of concern that patients attending CF summer camps may be at increased risk of acquiring *P. cepacia*, we investigated three summer camps from June to August 1990 to determine the incidence of, risk factors for, and possible modes of acquisition of *P. cepacia* by patients with CF at camp.

BACKGROUND

Three camps attended by a total of 270 patients with CF were studied. All three camps had campers and counselors known to have *P. cepacia* infection, but the prevalence of *P. cepacia*-infected patients differed.

Camp A—Ohio. From June 9 to 16, 1990, an annual 7-day camp was held for patients with CF from three CF centers in Ohio and one in Kentucky. Patients aged 6 to 14 years were eligible as campers; 15- to 17-year-old patients were admitted as counselors-in-training, and patients ≥ 18 years old were "staff members." Campers were housed in groups of five to nine individuals, according to age and sex, in 10 separate cabins. Each camper had one staff member who supervised him or her 24 hours a day, administered respiratory therapy, and performed chest physiotherapy. A total of 87 patients with CF, including three *P. cepacia*-infected patients, attended Camp A.

Camp B—Utah. From July 21 to 28, 1990, a 7-day camp was conducted for patients from one CF center in Utah. Patients 6 to 45 years of age were eligible. Most campers were housed according to age and sex, in groups of two to six, in 15 separate cabins or tents. Each group was supervised by one or more staff members. Some campers stayed in private tents or camping vehicles with family members. A total of 67 patients with CF, including 10 who had *P. cepacia* infection, attended Camp B.

Camp C—Ontario. From August 4 to 31, 1990, a 28-day camp was sponsored for patients from four CF Centers in Ontario. Patients aged 5 to 14 years were eligible as campers, patients aged 14 to 17 years were admitted as counselors/staff-in-training, and patients aged ≥ 18 years were

employed as counselors/staff members. Campers were grouped according to age and sex, 5 to 10 members in each group, housed by group in 13 cabins, and supervised by two or three staff members per group. A total of 114 patients, including 37 known to have *P. cepacia* infection, attended Camp C.

At each of the three study camps, campers participated in many outdoor and indoor activities, including swimming, other water sports, and dancing. Cabin mates shared many activities and were not restricted from mingling with campers from other cabins. Individualized medical care, including both intravenous and oral administration of medications, respiratory therapy, and chest physiotherapy, was provided by volunteer medical, paramedical, and lay staff members according to instructions from patients' attending physicians. Hand washing before and after chest physiotherapy and after handling potentially contaminated articles was not routinely performed, and patients were not assigned to a cohort according to their *P. cepacia*-colonization status. Aerosol therapy and chest physiotherapy were administered one to four times each day in each camper's cabin or in a common area. Each camper used his or her own medication nebulizer daily.

CF	Cystic fibrosis
CI	Confidence interval
EDTA	Ethylenediaminetetraacetic acid
RR	Relative risk

METHODS

Identifying the study patients

Campers. Informed consent was obtained from each patient with CF who was ≥ 18 years of age or from each minor patient's guardian. To determine colonization status, we obtained a sputum or throat culture specimen from each consenting patient on arrival at camp, and the results of the previous sputum cultures were obtained from the patient's CF center physician. A camper was considered uninfected if his or her culture was negative for *P. cepacia* on arrival at camp, if at least one sputum/throat culture specimen per year had been obtained during the 2 years preceding camp, and if no previous culture had been positive for *P. cepacia*. Five campers (two from Camp A and three from Camp C) who were uninfected on arrival and during camp, but who had at least one culture positive for *P. cepacia* during the 2 years preceding camp, were excluded from the analysis. A camper was considered infected if he or she had positive culture results for *P. cepacia* on arrival at camp.

Noncampers. Noncamper control subjects were patients with negative culture results for *P. cepacia* who attended the same CF centers as campers, had received outpatient or in-

patient care at their respective CF centers during the 2-week period before camp, and who had never previously had a culture positive for *P. cepacia*, including any of at least three sputum or throat cultures (one per year in the preceding 2 years, and one during the 2-week period before the respective CF center's summer camp started).

Incidence of *P. cepacia* acquisition, campers versus noncampers. Acquisition of *P. cepacia* by campers was determined by obtaining sputum or throat culture specimens from uninfected campers at the end of the 7-day camps (Camp A, Camp B), or weekly at the 28-day camp (Camp C), and on follow-up at 14 to 30 days after the end of camp. For noncampers, follow-up sputum or throat culture specimens also were obtained 14 to 30 days after the last day of the respective camps. We compared the cumulative incidence of sputum conversion in campers at the end of camp and at the end of the follow-up period with the incidence of sputum conversion in noncampers.

Potential exposures at camp. To evaluate potential risk factors for sputum conversion at camp, we asked all participating campers, their respective counselors, or both to complete questionnaire forms daily at Camps A and B, or weekly at Camp C. The questionnaire assessed each camper's close contact with other campers and staff members, frequency of respiratory therapy and chest physiotherapy, frequency of hand washing, and potential exposure to other potential environmental sources of *P. cepacia*. In addition, for each uninfected camper and noncamper, the respective CF center director completed a follow-up questionnaire regarding the patient's age, gender, severity of CF, respiratory culture results from 1988 and 1989, and potential exposures to patients with culture findings positive for *P. cepacia*, to environmental sources of *P. cepacia*, and to antipseudomonal antimicrobial agents received during the follow-up period.

Statistical methods. The point estimate of the relative risk of sputum conversion in campers compared with noncampers and its 95% confidence interval were calculated. The chi-square test for trends was used to determine the linear association between the incidence of sputum conversion and the prevalence of previously known *P. cepacia*-infected campers. Proportions were compared with the Fisher Exact Test or the chi-square test where appropriate. In the analysis of camp-associated risk factors for sputum conversion, the point RR and its 95% CI were calculated for categorical variables. The Mann-Whitney rank sum test was used to compare the difference in mean age between the campers and noncampers.

Collection, transport, and processing of specimens. At camp, investigators obtained sputum or throat culture specimens from all study patients after the patients' morning chest physiotherapy. Sputum or throat culture speci-

mens were obtained from noncamper control subjects during their outpatient visit or hospitalization within the 2-week period before the start of the respective CF center's camp.

A throat swab consisted of a complete swab of the posterior, anterior, and lateral portions of the patient's pharyngeal wall with a sterile throat swab, performed immediately after the patient attempted to cough. Throat swabs were placed into transport medium. Sputum specimens were collected in sterile screw-capped containers. All specimens were packed securely and shipped at ambient temperature overnight to the Centers for Disease Control and Prevention (CDC). Excellent recovery of *P. cepacia* organisms has been demonstrated in sputum culture specimens maintained at 25° C to 30° C for up to 14 days (CDC: unpublished data).

Follow-up culture specimens were obtained from campers and noncampers during their outpatient visit or hospitalization between 14 and 30 days after camp by CF center health care workers. Patients who did not return to their respective CF centers during the 14 to 30 days after camp were each given a sputum collection cup and a throat swab and were directed either to collect a sputum specimen at home or to have a throat culture specimen obtained by a local health care worker. Patients airmailed their culture specimens to the CDC.

Immediately on arrival at the CDC, sputum specimens were homogenized in a vortex mixer for 2 minutes. A sterile cotton swab was dipped into the homogenized sputum and swirled 12 times, and then the sputum was inoculated onto sheep blood-agar and *P. cepacia*-agar plates (BBL Microbiology Systems, Cockeysville, Md.).¹² Throat swabs were directly inoculated onto blood-agar and *P. cepacia*-agar plates. Plates were incubated at 35° C for up to 96 hours and examined daily. Phenotypically different strains were harvested separately and identified individually. Microorganisms were identified by means of conventional and automated biochemical tests (MicroScan Walk/Away, Baxter Diagnostics, Inc., Microscan Division, West Sacramento, Calif.*).¹³

Water from pools, lakes, drinking fountains, sinks, and showers at each camp was collected in 500 ml samples into sterile containers and shipped at ambient temperature overnight to the CDC. At the CDC, viable cell counts were determined by the membrane filtration technique.¹⁴ Aliquots of 1 ml and 50 ml of 10-fold serial dilutions of each water specimen were passed through 0.45 μ m membrane filters, and the filters were inoculated onto MacConkey-

*Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

Table. Assessment of potential risk factors for acquisition of *P. cepacia* among CF campers in Ohio, Utah, and Ontario in 1990

Exposure	<i>P. cepacia</i> acquisition among campers			
	Exposed proportion (%)	Unexposed proportion (%)	RR	(95% CI)
Shared item with <i>P. cepacia</i> -infected camper	3/9 (33)	6/161 (4)	8.9	2.7-30.1
Danced with <i>P. cepacia</i> -infected camper	3/18 (17)	6/152 (4)	4.2	1.2-15.4
Slept in cabin with <i>P. cepacia</i> -infected camper	7/61 (11)	4/130 (3)	3.7	1.1-12.3
Kissed <i>P. cepacia</i> -infected camper	1/21 (5)	8/149 (5)	0.9	0.1-6.7
Hugged <i>P. cepacia</i> -infected camper	4/45 (9)	5/125 (4)	2.2	0.6-7.9
Ate any fresh fruit or vegetables	7/164 (4)	2/6 (33)	0.1	0.03-0.5
Washed hands \leq 3 times a day	3/68 (4)	6/102 (6)	0.8	0.2-2.9

blood-, and *P. cepacia*-agar plates. Culture plates were incubated at 35° C for up to 96 hours and examined daily for growth of organisms.

Ribotyping of *P. cepacia*. By means of ribotyping, a technique for detecting DNA fragments carrying ribosomal ribonucleic acid genes, we compared phenotypically distinct isolates from patients who became infected with isolates from all known *P. cepacia*-infected camp attendees participating in the study. Preliminary experiments were done with DNA extracts from four strains used to serotype *P. cepacia* by use of restriction digests of *Bam*HI, *Bgl* II, *Cla* I, *Eco*RI, *Hind*III, *Not* I, *Pst* I, *Pvu* I, *Sfi* I, and *Sma* I to select the enzyme or enzymes that provide the best discrimination of hybridization banding patterns.^{14a} Ribotyping analysis of the *P. cepacia* isolates from study patients was subsequently performed by use of *Eco*RI and *Cla* I restriction digests. The resulting fragments were separated by gel electrophoresis in 1.0% agarose in Tris-acetate-EDTA buffer, and transferred onto a nylon membrane (Magna-Graph Nylon, Micron Separations, Inc., Westborough, Mass.). Membranes were probed with digoxigenin-labeled complementary DNA derived from reverse transcription of 16S/23S ribosomal RNA; hybridization bands were detected directly by an immunologic method (Genius System, Boehringer-Mannheim, Indianapolis, Ind.). Because *Cla* I digests, which produced 9 to 12 bands, provided greater discriminatory capacity than *Eco*RI digests, which typically yielded 5 to 10 bands, they were used for the final determination of relatedness of isolates from patients with *P. cepacia* sputum conversion and other camp attendees.

RESULTS

Of the 270 campers, 237 (88%) agreed to participate in the study. (The 33 nonparticipants were similar to the participants in age and sex. Four [12%] had *P. cepacia* infection before camp; all four attended Camp C.) Of the 237

participants, 191 (81%) had cultures negative for *P. cepacia* on arrival at camp and had never previously had cultures positive for *P. cepacia*. The median age of these study patients was 12 years (range, 5 to 45 years); 98 (51%) were male subjects. Of the participating campers, 46 (19%) had culture findings positive for *P. cepacia*. The prevalence of *P. cepacia*-infected campers at the beginning of camp varied among the three camps: 3 (3.4%) of 87 at Camp A, 10 (15.9%) of 63 at Camp B, and 33 (37.9%) of 87 at Camp C.

Incidence of acquisition of *P. cepacia*. Of 191 campers with initial culture findings negative for *P. cepacia*, 10 (5.2%; 95% CI = 2.7% to 9.7%) had one or more positive culture results during camp (range: 1 to 4 positive culture results per converter). Sputum or throat specimens cultured 14 to 30 days after camp for 181 (95%) of 191 campers with initially negative results showed that one additional camper had sputum conversion. This camper had five weekly cultures negative for *P. cepacia* while at Camp C but a positive culture result 2 weeks after camp. Thus the cumulative incidence of sputum conversion in campers with results negative for *P. cepacia* who completed the follow-up was 11 (6.1%) of 181 (95% CI = 3.2% to 10.9%).

The risk of sputum conversion in campers with negative culture results increased with an increase in the prevalence of *P. cepacia*-infected persons at camp: none of the 84 at Camp A (prevalence of *P. cepacia*-infected campers: 3.4%); 2 (4.3%) of 47 at Camp B (prevalence: 15.9%); and 9 (18.0%) of 50 at Camp C (prevalence: 37.9%) ($p < 0.001$, chi-square test for trend). In addition, the risk of sputum conversion was significantly higher in the camp with the longer duration: 9 (18%) of 50 persons at Camp C (duration: 4 weeks) versus 2 (1.5%) of 131 at Camp A and Camp B (duration: 1 week each) (RR = 12.0; 95% CI = 2.7% to 53.5%).

In addition to the camper whose sputum conversion was

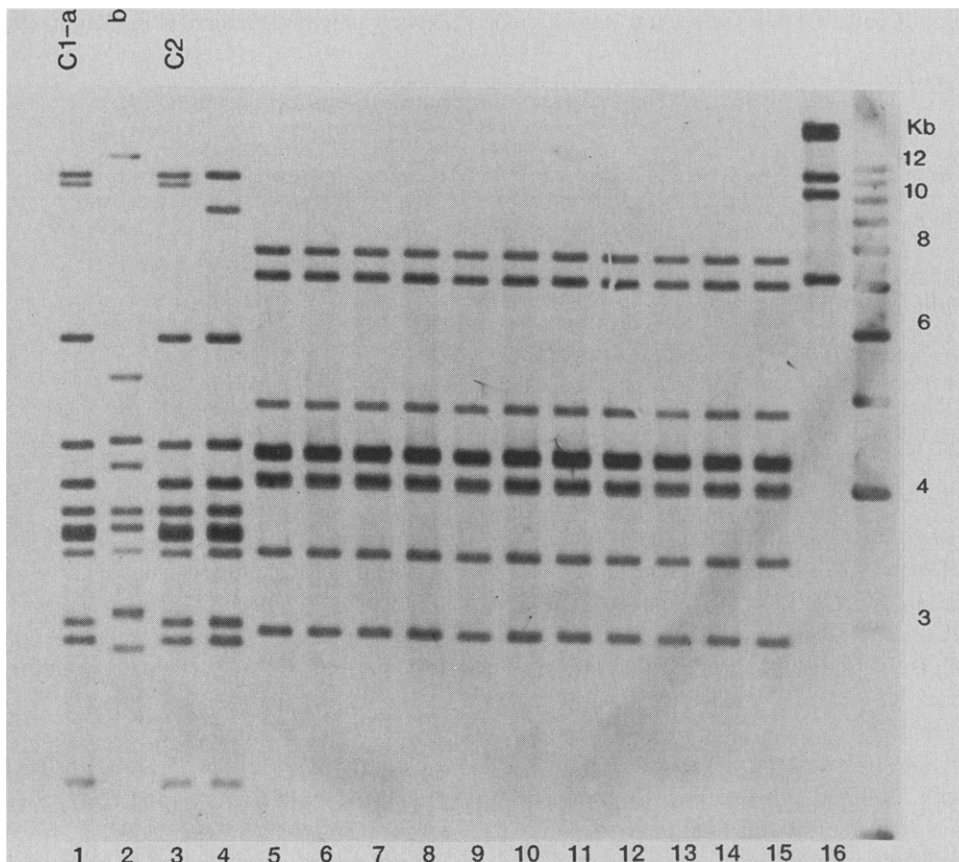


Fig. 4. Ribotyping of *Cla* I-digested DNA from *P. cepacia* isolates, Camp B, Utah. *P. cepacia* isolates from the first subject with sputum conversion (lanes 1 and 2, marked C1-a and C1-b, respectively), the second with conversion (C2, lane 3), 12 *P. cepacia*-infected campers (lanes 4 to 15), and water from a picnic jug (lane 16). Size markers in kilobase pairs = migration of *Hind*III-digested lambda phage DNA (lane 17). One of two *P. cepacia* isolates from the first subject with sputum conversion (C1-a, lane 1) had the same banding pattern as the isolate from the second subject with conversion (C2, lane 3) and was very similar to (i.e., had one band different from, and 11 bands identical with) the ribotype of an isolate from a known *P. cepacia*-infected camper (lane 4) with whom they reported close contact. The first converter's second *P. cepacia* isolate had a unique ribotype (C1-b, lane 2) that was different from all other ribotypes found at that camp.

first detected 2 weeks after camp, only 3 of the 10 subjects with sputum conversion at camp had a culture positive for *P. cepacia* on follow-up. Thus if a point estimate of the incidence of sputum conversion in campers had been done only at the end of the follow-up period (as was done for noncampers), it would have been 4 (2.2%) of 181 (95% CI = 0.7% to 5.9%).

During 12 additional months of observation, *P. cepacia* was recovered intermittently from sequential respiratory cultures from 4 (36%) of the 11 subjects with sputum conversion (range, 2 to 4 positive culture results per converter).

Association between attendance at camp and acquisition of *P. cepacia*. None of 92 noncamper control subjects with follow-up cultures had a sputum conversion (upper limit of 95% CI = 5.0%); thus the cumulative incidence of sputum conversion by the end of the 4-week follow-up period was

significantly higher in campers than in noncampers (11 [6.1%] of 181 vs none of 92; $p = 0.02$, Fisher Exact Test). However, if the analysis had been restricted to the follow-up cultures alone, the incidence of *P. cepacia* acquisition among campers and noncampers would not have been significantly different (4 [2.2%] of 181 vs none of 92; $p = 0.30$, Fisher Exact Test).

In comparing campers with negative culture results and noncamper control subjects to determine whether the higher incidence of sputum conversion in campers may have been partly the result of differences in patient characteristics, we found that campers with negative culture results were significantly younger (mean age: 11.8 years vs 13.5 years; $p = 0.02$) and had milder underlying CF (mild CF: 103 [61%] of 170 vs 36 [39%] of 92; $p < 0.001$, chi-square test). However, the two patient groups had similar sex dis-

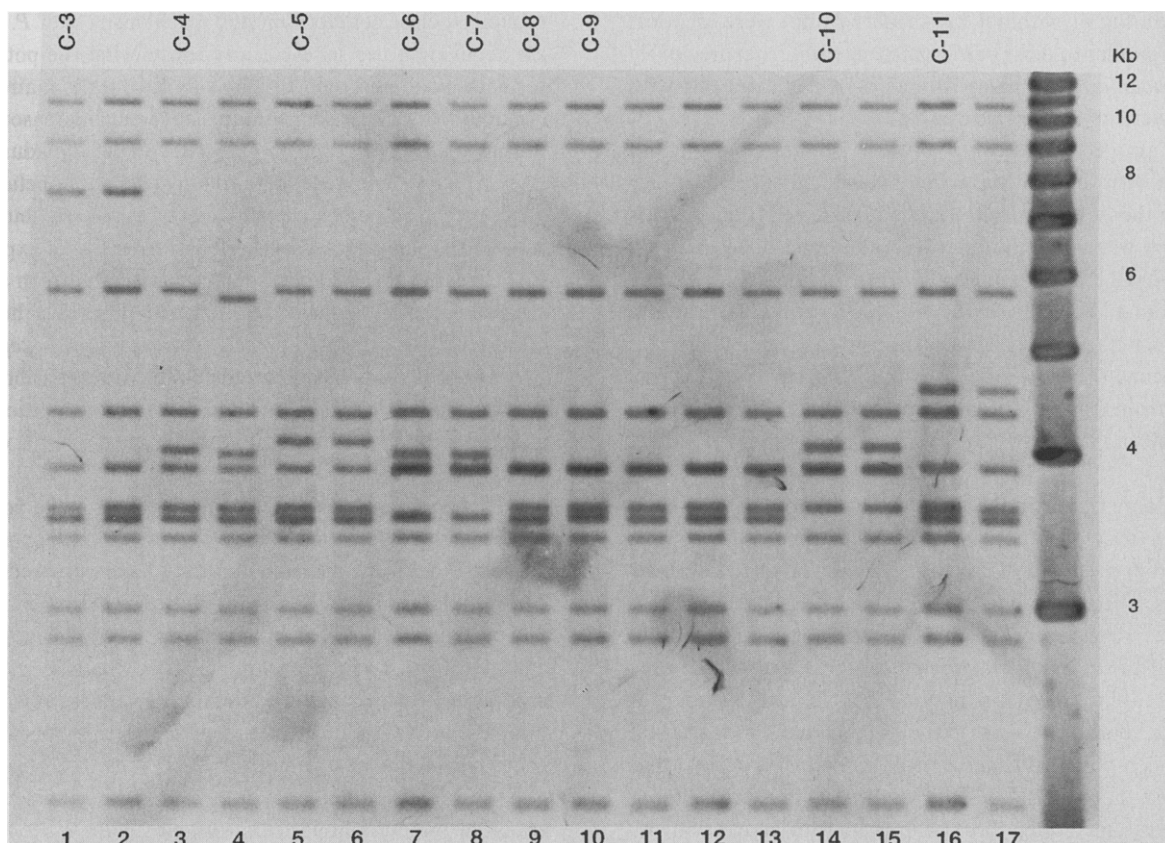


Fig. 2. Ribotyping of *Cla* I-digested DNA from *P. cepacia* isolates, Camp C, Ontario. *P. cepacia* from nine Camp C campers who acquired *P. cepacia*: C3 (lane 1), C4 (lane 3), C5 (lane 5), C6 (lane 7), C7 (lane 8), C8 (lane 9), C9 (lane 10), C10 (lane 14), C11 (lane 16); and isolates from other *P. cepacia*-infected Camp C campers (lanes 2, 4, 6, 11 to 13, 15, and 17). Size markers in kilobase pairs = migration of *Hind*III-digested lambda phage DNA (lane 18). The *P. cepacia* isolates from subjects with conversion C3 (lane 1) and C9 (lane 10) had ribotypes identical to those of isolates from campers (lanes 2 and 11, respectively) with whom they reported close contact for the duration of camp. The ribotype of the *P. cepacia* isolate from converter C9 also matched that of *P. cepacia* isolates from another converter (C8, lane 9) and two other known *P. cepacia*-infected campers (lanes 12 and 13); however, converter C9 did not report close contact with these individuals at camp, and they attended different CF centers. The seven remaining subjects with sputum conversion had *P. cepacia* isolates with ribotypes that matched those of isolates from *P. cepacia*-infected Camp C attendees (including those with conversion during camp) with whom no close contact was reported: C4 (lane 3) and lane 4, with one band difference among 12 bands; C5 (lane 5) and lane 6; C10 (lane 14) and lane 15; C11 (lane 16), and six other campers (common ribotype shown in lane 17); and converters C6 (lane 7) and C7 (lane 8) who had no documented exposure between them and were from different CF centers. The latter ribotype was not found in any of the available isolates from 33 of 37 *P. cepacia*-infected campers.

tributions (male subjects: 95 [52%] of 181 campers with negative results vs 47 [51%] of 92 control subjects), and similar proportions of patients whose cultures colonized *P. aeruginosa* organisms in 1988 to 1989 (114 [63%] of 181 vs 66 [72%] of 92, respectively; $p = 0.15$, chi-square test).

Risk factors for *P. cepacia* acquisition at camp. The 11 subjects with sputum conversion did not differ from the 180 without conversion in age, sex, or severity of underlying CF. Data from camp questionnaires that were completed by 9 of 11 subjects with sputum conversion and 170 of 180 without conversion revealed that the risk of sputum conversion

was significantly higher among those who reported having slept in the same cabin, shared an item, or danced with a *P. cepacia*-infected camper (Table). The risk of *P. cepacia* acquisition was not significantly greater among those who reported having hugged or kissed a *P. cepacia*-infected camper or washed hands infrequently, and was significantly less for those who reported having eaten fresh fruit or vegetables (Table).

Ribotyping. Restriction fragment length polymorphisms (i.e., ribotypes of *P. cepacia* isolates from all 11 campers whose sputum culture or cultures became positive for *P. ce-*

pac during or within 4 weeks after camp) were identical or very similar to those of *P. cepacia* isolates from previously *P. cepacia*-infected camp attendees or from subjects with co-conversion in the same camp.

In Camp B, one of two *P. cepacia* isolates from the first subject with sputum conversion had the same banding pattern as the isolate from the second converter (Fig. 1). This ribotype was very similar to (i.e., had one band different from, and 11 bands identical with) the ribotype of an isolate from a known *P. cepacia*-infected camper with whom the two with sputum conversion shared sleeping quarters and spent >4 hours a day at camp. This ribotype was different from the common ribotype of *P. cepacia* isolates from the other nine known *P. cepacia*-infected Camp B participants.

At Camp C, all nine subjects with sputum conversion had *P. cepacia* isolates that closely matched the ribotype of isolates from previously known *P. cepacia*-infected camp attendees or from those with co-conversion (Fig. 2). Of these nine, two (converters C3 and C9) had ribotypes identical to those of the *P. cepacia*-infected campers with whom they shared cabins, spent >4 hours a day for the duration of camp, or both. The seven remaining subjects with sputum conversion had *P. cepacia* isolates with ribotypes that matched those of isolates of *P. cepacia*-infected Camp C attendees (including those whose sputum conversion occurred at camp) with whom no close contact was reported.

Water samples. Of the 36 water samples obtained from the three study camps, only a specimen of ice water obtained from a picnic jug at Camp B contained *P. cepacia*. However, the ribotype of this *P. cepacia* isolate was different from that of isolates from the two Camp B subjects with sputum conversion (Fig. 1). No *P. cepacia* organisms were isolated from the other samples, which included water from sinks (n = 12), showers (n = 10), lakes and ponds (n = 5), swimming pools (n = 5), and drinking fountains (n = 3).

DISCUSSION

Nosocomial acquisition of *P. cepacia* by patients with CF has been strongly suggested,^{3,9} but *P. cepacia* acquisition at patients' homes, outpatient clinics, and summer camps has not been well studied.^{6,10,11,15} The epidemiologic and laboratory findings of this investigation strongly suggest that *P. cepacia* can be acquired at CF summer camps, and that one of the possible modes of *P. cepacia* transmission at camp is by person-to-person contact.

Previous studies suggest that person-to-person transmission is one likely mode of *P. cepacia* acquisition.^{2,8-11} In this investigation, we found that campers with sputum conversion were more likely than those with no conversion to have reported specific exposures to other *P. cepacia*-infected campers. These exposures are more likely to be proxies for

prolonged close contact than the mechanism(s) of *P. cepacia* acquisition per se, especially considering the potential for both recall and reporting bias in the questionnaire. We also found that the risk of sputum conversion increased with the prevalence of *P. cepacia*-infected campers and duration of camp. These epidemiologic findings do not conclusively prove person-to-person transmission of *P. cepacia*, but they suggest that an increased duration or intensity of exposure to *P. cepacia*-infected campers was associated with an increased risk of *P. cepacia* acquisition at camp and they are consistent with person-to-person transmission of *P. cepacia*.

A previous study has reported possible transmission of *P. cepacia* from *P. cepacia*-infected to uninfected patients at a 7-day camp.¹⁵ Within 3 months after camp, 9.1% of patients susceptible to *P. cepacia* infection acquired *P. cepacia*. However, because none of these campers had a positive sputum culture result on the last day of camp, the possibility that *P. cepacia* transmission may have occurred after camp could not be excluded. In addition, the risk of *P. cepacia* acquisition among noncampers was not rigorously assessed. In studies of transmission of *P. aeruginosa* (a microorganism with similar epidemiologic characteristics in patients with CF) in CF summer campers, transmission could not be demonstrated.^{16,17}

Nosocomial outbreaks of *P. cepacia* respiratory colonization or infection in patients without CF have been associated with environmental contamination of disinfectants, antiseptics, and water.^{1,2,4,18-20} However, an environmental source did not appear to be responsible for *P. cepacia* transmission in the study camps. Respiratory therapy devices should not have been involved in *P. cepacia* transmission at the camps, because these devices were not shared between patients and were routinely discarded after less than 24 hours of use by a single person.

In this investigation, we used sputum conversion from negative to positive culture results as the indicator of new *P. cepacia* acquisition. Upper airway culture is a sensitive method of detecting established lower airway, non-*P. cepacia* bacterial colonization in patients with CF.^{21,22} However, the sensitivity of sputum or throat culture methods in detecting new lower airway acquisition of *P. cepacia* is not known and may be affected by factors such as specimen handling and processing, the density of microorganisms in the lower airway, the severity of the patient's lung disease, and the patient's effort to cough. Anecdotal accounts have suggested that sputum culture methods might not be highly sensitive in prompt identification of new or intermittent *P. cepacia* colonization in patients with CF,^{8,11} although *P. cepacia* transmission from patients with CF who have negative culture results has not been shown. Application of new techniques, such as use of the polymerase chain reaction, may improve the detection of new *P. cepa-*

cia acquisition in the respiratory tract and help to elucidate the mechanisms and risks of transmitting *P. cepacia* between CF patients. In the interim, however, in response to the concerns noted above, as well as the results of this and other camp and noncamp studies, the U.S. Cystic Fibrosis Foundation issued a recommendation to discontinue CF summer camps (U.S. CF Center Directors Committee, 1993).

We used ribotype analysis to link subjects with sputum conversion and the *P. cepacia*-infected campers. However, nonparticipation in the study by some campers limited our ability to assess completely the ribotype patterns at Camp C. Of the 24 Camp C campers who did not consent to participate in the study, 4 were known to have *P. cepacia* infection and could have served as sources of *P. cepacia*. In addition, the use of a weekly rather than a daily exposure questionnaire may have limited the ability of campers attending Camp C to recall and enumerate contacts with other campers for each 7-day period.

In the acute care hospital setting, the use of contact isolation precautions for the prevention of nosocomial transmission of multi-drug-resistant bacteria, including *P. cepacia*, has been recommended by the CDC.²³ This study did not assess the degree to which contact isolation precautions were observed at each camp. Thus the impact of these precautions on reducing the risk of *P. cepacia* transmission at camp or in other settings outside the hospital has not been determined. However, strict observance of contact isolation precautions or cohort assignments of campers with CF by their *P. cepacia* colonization status at CF summer camps or other settings outside the hospital may be impractical and may impair the social and interactive purpose of such gatherings.

On the basis of results of this and other camp studies, the CDC has recommended that in CF camps where transmission of *P. cepacia* has been suspected, or where the expected prevalence of *P. cepacia*-infected campers is >5%, and/or where the duration of camp is longer than 1 week, the following should be considered: either full implementation of contact isolation precautions at the CF summer camp or prohibition of attendance of *P. cepacia*-infected and uninfected patients at the same CF camp at the same time. In areas with a high prevalence of *P. cepacia*-infected patients, separate camps for infected and uninfected patients may be feasible.²⁴

These recommendations depend on adequate procedures for screening patients before camp. Therefore, until more sensitive methods of detecting *P. cepacia* in the respiratory tract of CF patients become available, it is essential that sputum or throat culture specimens be appropriately collected from patients with CF and transported to and processed in a laboratory that routinely uses *P. cepacia*-se-

lective media, and by personnel who are proficient in isolating and identifying *P. cepacia* from sputum of patients with CF.²⁵

The recommendations discussed above represent the minimum precautions to be taken if CF summer camps are to be held, because the risk of transmission, albeit small, may be present in camps where an infected patient is in attendance. The recommendations are not meant to restrict CF centers or summer camps from requiring additional precautions or adopting a more stringent approach.

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