JANET C. MOHLE-BOETANI, MD ■ CHANTAL MATKIN, MPH
MARK PALLANSCH, PHD ■ RITA HELFAND, MD
MARTIN FENSTERSHEIB, MD MPH ■ JUDITH A. BLANDING, MSN
STEVEN L. SOLOMON, MD

Viral Meningitis in Child Care Center Staff and Parents: An Outbreak of Echovirus 30 Infections

Dr. Mohle-Boetani is a Medical Epidemiologist, Disease Investigations and Surveillance Branch, California Department of Health Services, Berkeley; at the time of this investigation, she was a Centers for Disease Control and Prevention (CDC) Preventive Medicine Resident, Santa Clara County Public Health Department, San Jose, CA. Ms. Matkin is a graduate student, Department of Health Research and Policy, Stanford University; at the time of this investigation, she was a Research Assistant with the Santa Clara County Public Health Department. Drs. Pallansch and Helfand are with the Respiratory and Enteroviruses Branch, CDC, Atlanta; Dr. Pallansch is Chief of the Enterovirus Section, and Dr. Helfand is a Medical Epidemiologist. Dr. Fenstersheib and Ms. Blanding are with the Santa Clara County Public Health Department; Dr. Fenstersheib is the Health Officer, and Ms. Blanding is the Child Group Health Services Coordinator. Dr. Solomon is Chief, Special Studies Activity, Hospital Infections Program, CDC, Atlanta.

SYNOPSIS

Objective. A report of five cases of viral meningitis among adults with children enrolled in a child care center prompted an investigation of risk factors for viral transmission from children to adult household members.

Methods. To determine recent echovirus 30 (E30) infections, the authors conducted a serologic survey. To determine risk factors for infection among adult household members, they conducted a retrospective cohort study using written questionnaires.

Results. Recent E30 infections were found in 84% of children tested, 57% of adult household members tested, and 47% of staff members tested. Infected adults were more likely than infected children to have clinical meningitis. Among adult household members, changing diapers was a risk factor for recent infection. Women who changed ≥ 90 diapers per month had a higher infection rate than women who changed fewer diapers; in contrast, men who changed ≥ 90 diapers per month had a lower infection rate than men who changed fewer diapers. Handwashing was protective: there was a negative correlation between handwashing after diaper changes and E30 infection among adults with infected children in diapers.

Conclusions. Because child care centers can be a source of enteroviral infections among adult household members, adults with viral meningitis should be questioned about their children's day care or preschool attendance. The importance of handwashing should be stressed to adults with children in day care.

Address correspondence to:
Dr. Mohle-Boetani, DISB, DCDC, CA Dept. of Health Services, 2151 Berkeley Way, Rm. 708, Berkeley CA 94704; tel. 510-540-2566; fax 510-540-2570; e-mail <jmohlebo@dhs.ca.gov>.

Transmission of infectious diseases within child care centers, transmission from children in day care to adults in their homes and to child care providers, and appropriate preventive measures are well documented.[1–3] However, there have been few investigations of the risk factors for transmission of infectious agents from children in grouped child care to their adult household members. Identification of these risk factors is important in developing prevention strategies for families. An outbreak of viral meningitis among a cluster of adults with children attending the same child care center provided us with an opportunity to (*a*) investigate transmission of an enterovirus from infected children to their adult household members and (*b*) identify risk factors for infection among adults with infected children. We also examined how transmission differed by the sex of the adult household member.

The outbreak. On November 15, 1992, a child care center director reported to the Santa Clara County Health Department that from November 1 through November 14, five parents of children attending the center had been diagnosed with viral meningitis. We initiated an investigation on November 15.

After confirming the diagnosis through medical record review, we determined the causative agent by culturing specimens from the five parents with meningitis and their children. We isolated echovirus 30 (E30) in stool samples from all five center children whose parents had meningitis and from three parents with meningitis; no other viral agent was isolated. E30 was also isolated from the cerebrospinal fluid of one of the three parents who had stool cultures positive for E30. Two parents hospitalized with meningitis did not submit stool samples; neither E30 nor any other pathogen was identified in their cerebrospinal fluid.

Surveillance for viral meningitis in Santa Clara County, including a request to all hospitals to report diagnosed cases, did not show evidence of a communitywide outbreak. This suggested that the five parents with meningitis acquired E30 infections from their children attending the child care center.

Outbreak control. The child care center cared for 88 children from 64 households; they were grouped by age in seven classrooms. The children were 6 weeks to 6 years old; 50% wore diapers. On the first day of our investigation we observed several behaviors that would encourage fecal-oral spread between staff and children, including frequent rotation of staff members and children between classrooms, commingling of groups of children, and inconsistent handwashing by staff and children after diaper changing and by children after using the toilet. Proper hygiene was impaired in part because the sink in the classroom for 18-month-old children was nonfunctional and there was no sink in the pre-kindergarten classroom.

To control the outbreak, we provided these recommendations to the director based on our observations: (*a*) repair the nonfunctional sink, (*b*) limit rotation of staff and children between classrooms, (*c*) require handwashing of children or adults or both as appropriate upon entry to another playgroup or classroom, after diaper changing, before eating, and before preparing or serving food, (*d*) prohibit diaper changing by staff who prepare food, and (*e*) daily cleaning and disinfection of toys. We also conducted a one-hour training session for the staff on handwashing, cleaning of toys, and diapering procedures.

We then monitored the center for implementation of these recommendations by openly observing for one to three hours per day on 10 separate days over a three-week period and for three hours on a day six weeks after we provided the recommendations. We observed adherence with all recommendations except for limiting rotation of staff and children between classrooms; the director stated that rotation was required to maintain the necessary child-to-staff ratio. No cases of meningitis occurred after we provided our recommendations to the director.

METHODS

Definitions. The outbreak period was from October 15, 1992, through November 15, 1992. We defined viral meningitis as: (*a*) self-reported illness with fever, headache for two or more days, and a stiff neck; or (*b*) physician-diagnosed illness confirmed by a lumbar puncture with at least five white blood cells per high-power field and a culture yielding no bacterial growth. This is the definition used in an investigation of an earlier E30 outbreak in a child care center in Southern California (approximately 400 miles away from the center described in this report).[4]

Extent of illness. We also conducted a retrospective cohort study to determine the extent of illness in staff, children, and their family members, We provided a self-administered written questionnaire to all staff and to

the adult household members of children attending the center. One questionnaire was completed per household. All 16 staff members and all 64 families participated. The 64 families included 151 adults and 115 children (88 who attended the center and 27 who did not). For each staff member and each household member, including children, we collected the following information: age; symptoms of illness during the outbreak period ("runny nose," cough, vomiting, diarrhea, "light hurting eyes," fever, and headache); duration of each symptom; days of hospitalization; and days missed from work due to illness in the family.

Serologic survey. We identified recent E30 infections by testing for Immunoglobulin M (IgM) antibodies to E30 among children, adult household members of children attending the center, and staff. We obtained informed consent for the blood testing from adults and from the parents or guardians of children participating in the survey. Fifteen (94%) of 16 staff members, 122 (81%) of 151 adult household members, and 75 (85%) of 88 children who attended the center participated in the serologic study.

We collected blood samples on filter paper using a fingerstick. We extracted sera from filter paper and tested for IgM antibodies to E30 by adapting a previously described capture enzyme immunoassay.[5] This is the same assay used in the earlier E30 outbreak investigation in a child care center.[4] We used E30 (Bastiani) as the antigen and biotinylated anti-E30 IgM monoclonal antibody 505-2G-6A-8D as the detector antibody. We defined a positive specimen as a result two or more standard deviations above the mean optical density of negative controls. One of the present authors (MP) estimates the sensitivity for detection of recent enteroviral infection with this assay to be 95%. Although this assay is not completely specific for E30 infection because of heterotypic antibody response from related enteroviruses, in the context of this E30 outbreak, a positive assay result had a high likelihood of being the result of an infection with E30. (Given a sensitivity of 95%, even with a specificity of only 50%, the positive predictive value would be 95%.)

Risk factors among adult household members. To determine risk factors for recent E30 infection among adult household members, we asked all adult household members who participated in the serologic survey to fill out a second questionnaire. Unlike in the earlier investigation,[4] in which one adult household member answered behavior questions for all adults in the household, participants in our study answered questions only about their own interactions with their children.

All respondents answered the questionnaire prior to receipt of serology results; most returned the questionnaire four months before receiving serology results. We collected information about interactions with children that could result in exposure to stool or saliva (for example, diaper changing, kissing, nose wiping, and sharing utensils); interactions that involved close contact (for example, sleeping in the same bed); and about handwashing after diaper changing and after returning home from the center.

We evaluated risk factors for transmission from children to household members using the questionnaire responses of adult household members of children who were tested and found to have had recent E30 infections.

Statistical methods. For all statistical calculations, we used the software package Epi-Info.[6] For dichotomous variables, we calculated relative risks (RR), 95% confidence intervals (CI), and Mantel-Haenszel or Fisher's exact 2-tailed test *P* values.

RESULTS

Extent of illness. Eighteen (11%) of 167 adults, including two staff members, had viral meningitis; of them, five were hospitalized. Three (3%) of 115 children, including one child who attended the center, had viral meningitis; none of the three was hospitalized. Forty-nine (29%) adults (including ill adults) missed one to 11 days of work (median 2 days) due to their own illness or illness in the family.

Serologic survey. Seven staff (47% of those tested), 69 adult household members (57% of those tested), and 63 children (84% of those tested) had serologic evidence of recent E30 infections. All five adults who were hospitalized for viral meningitis and all five children with E30 isolated from their stool had serologic evidence of recent E30 infection.

Of the 18 adults who reported symptoms consistent with viral meningitis, 17 were tested for IgM antibodies. Sixteen of the 17 had evidence of recent E30 infection. Of the three children with viral meningitis, the one child who attended the center was tested and had evidence of recent infection.

Children from all classrooms and in all age groups

Eighteen of 167 adults, including two staff members, had viral meningitis; five were hospitalized.

were infected. A higher percentage of children who wore diapers (89% [34/38]) than of children who did not wear diapers (78% [29/37]) were infected, although the difference was not significant.

Among the 69 recently infected household members, 60 had infected children, five had children with no evidence of recent infection, and four had children who were not tested.

Illness among infected individuals. The expression of illness differed for infected adults and infected children (Table 1). Infected adults were more likely than infected children to have meningitis ($P < 0.0005$) or a headache for more than one day ($P = 0.005$) and less likely to have rhinitis ($P = 0.003$). Five (7%) of infected adults were hospitalized, while no infected children were hospitalized. Forty-one percent of infected adults and 22% of infected children were asymptomatic.

Because headache is reported more reliably by adults than children and our definition of meningitis was dependent on the report of headache, we evaluated the duration of the more easily observable symptoms of fever and vomiting. The duration of fever or vomiting was significantly longer among infected adults with meningitis (median 3 days, range 2–30 days) than among other infected adults (median 0 days, range 0–7 days, $P< 0.001$) or among infected children (median 1 day, range 0–7 days, $P = 0.001$).

Risk factors among adult household members of infected children. Of the 102 adult household members of the 63 infected children, 95 were biological mothers or fathers and seven were other adults (one aunt, one uncle, two boyfriends of mothers, and three grandparents). Among adult household members with infected children, 59% (60/102) were infected.

Table 1. Reported illness among people with recent E30 infections, by age group: outbreak of viral meningitis associated with a child care center, Santa Clara County, California, October 15, 1992–November 15, 1992

	Viral meningitis					Headache > 2 days					Runny nose or cough				
Age group	Number	Percent	RR	95% CI	P value[a]	Number	Percent	RR	95% CI	P value[a]	Number	Percent	RR	95% CI	P value[a]
Adults[b] (n = 76)	16	21	13.3	1.8, 97.3	0.0005	25	33	2.6	1.3, 5.4	0.006	23	30	0.54	0.4, 0.8	0.003
Children attending the center (n = 63)	1	2				8	13				35	55			

NOTE: Illness categories are not mutually exclusive.
[a]Mantel-Haenzel chi square test
[b]Included 7 center staff and 69 adult household members of children who attended the center
E30 = echovirus 30
RR = relative risk
CI = confidence interval

Similar percentages of infected (90% [54/60]) and uninfected adult household members (85% [36/42]) participated in the risk factor survey. Ninety of the 102 adult household members with infected children completed a questionnaire concerning possible risk factors for becoming infected by their children.

Among the 90 adult household members completing the questionnaire who had infected children, those with children who wore diapers at home were more likely to be infected (69% [44/64]) than those with children who did not wear diapers (38% [10/26]) (RR = 1.8, CI 1.1, 3.0, P = 0.008). Among the 90 adult household members, all of those with children in diapers reported that they changed their children's diapers. When we stratified the data to control for diaper wearing by infected children, we found that no exposures to children other than diaper changing were associated with infection. Infection rates were similar for women (67%) and men (71%) who changed diapers.

For those with infected children among the adults responding to the questionnaire, handwashing was protective against infection. The adult household members who reported that they washed their hands at least some of the time after bringing their children home from the center had a lower rate of infection (50% [30/60]) than those who said they never washed their hands when returning home (79% [24/30]) (RR = 0.63, CI 0.40, 0.85, P = 0.006).

Among the 64 questionnaire respondents with infected children in diapers, those who said that they always washed their hands after changing diapers had a lower rate of infection (52% [13/25]) than those who washed their hands less regularly (80% [31/39]) (RR = 0.65, CI 0.43, 0.98, P = 0.02). No other handwashing behaviors were protective against infection.

We explored the association between diaper changing and infection further by assessing how the number of diapers changed affected the risk of infection among these 64 adults with infected children in diapers (Table 2). Those who changed ≥ 90 diapers per month had a rate of illness similar to those who changed fewer diapers per month (Table 2). However, the relationship between the number of diapers changed and infection was modified by the sex of the adult household member. Women who changed ≥ 90 diapers per month had a higher rate of infection (81%) than women who changed fewer diapers (30%, P = 0.007), but men who changed ≥ 90 diapers per month had a lower rate of infection (53%) than men who changed fewer diapers (92%, P = 0.04). Men who changed ≥ 90 diapers per month had a lower rate of infection than women who

Table 2. Association between diaper changing and recent echovirus 30 (E30) infection among adults with E30-infected children in diapers: outbreak of viral meningitis associated with a child care center, Santa Clara County, California, October 15,1992–November 15, 1992

Number of diapers changed per month	*Number*	*Recent E30 infection*				
		Number	*Percent*	*RR*	*95% CI*	*P value*
Adult household members (n = 64)						
≥ 90	41	29	70	1.08	0.76, 1.55	NS
< 90	23	15	65			
Women (n = 36)						
≥ 90	26	21	81	2.7	1.03, 7.07	0.007[a]
< 90	10	3	30			
Men (n = 28)						
≥ 90	15	8	53	0.6	0.35, 0.95	0.04[a]
< 90	13	12	92			

[a]Fisher's exact 2-tailed test
E30 = echovirus 30
RR = relative risk
CI = confidence interval
NS = not significant

Table 3. Handwashing and diaper changing among adults with E30-infected children: outbreak of viral meningitis associated with a child care center, Santa Clara County, California, October 15–November 15, 1992

Number of diapers changed per month	Number	Always washed hands after diaper changes				
		Number	Percent	RR	95% CI	P value
Adult household members (n = 64)						
≥ 90	41	16	39	1.0	0.53, 1.89	NS
< 90	23	9	39			
Women (n = 36)						
≥ 90	26	6	23	0.5	0.18, 1.18	NS
< 90	10	5	50			
Men (n = 28)						
≥ 90	15	10	67	2.2	0.89, 5.28	NS
< 90	13	4	31			

E30 = echovirus 30
RR = relative risk
CI = confidence interval
NS = not significant

changed ≥ 90 diapers per month, but this difference was not statistically significant.

We evaluated factors that might explain the sex-specific difference in the association between number of diapers changed and infection among the 64 questionnaire respondents with infected children in diapers. (See Table 3.) Of men who changed ≥ 90 diapers per month, 67% reported that they always washed their hands after diaper changes, while among men who changed fewer diapers, only 31% always washed their hands, although the difference was only of borderline significance. In contrast, only 23% of women who reported changing ≥ 90 diapers per month said that they always washed their hands after diaper changes, while 50% of those who reported changing fewer diapers said that they always washed their hands. Among adults who changed ≥ 90 diapers per month, men were significantly more likely (67%) than women (23%) to report that they always washed their hands after changing diapers ($P = 0.006$).

To explore other explanations for the lower infection rate in men than women among those who changed ≥ 90 diapers per month, we compared these 15 men and 26 women in terms of age (older age might be associated with prior exposure and protection from new infection) and other exposures to children. Men and women household members did not differ significantly in age or in exposures, including time spent in close contact with their children or the frequency of kissing or wiping the noses of their children.

DISCUSSION

The findings of this study support and expand on the findings described previously from a similar outbreak.[4] Both studies found high rates of E30 infection in adult household members and children. In addition, both studies found that E30-infected adults had higher rates of meningitis than E30-infected children. Past studies have suggested greater morbidity among adults than among children for E30 infections,[7] but these studies were limited because documentation of recent enteroviral infection required collection of two samples of venous blood or viral isolation from stool; in contrast, we could detect recent E30 infections using an IgM assay of blood collected from a fingerstick.

Because we surveyed a high proportion of both men and women adult household members with recently infected children, we were able to conduct an in-depth exploration of sex-specific risk factors for adult infections; these analyses were stimulated by a finding of a protective effect of handwashing among mothers of toddlers in the earlier study, which was limited by a small sample size and a low enrollment of fathers of infected children.[4] We found diaper changing to be an important risk factor. But we were surprised to find that adults

Adult household members of children in diapers were more likely to show evidence of recent E30 infection than adult household members of children who did not wear diapers.

with infected children who changed a greater number of diapers had a rate of infection similar to those who changed fewer diapers. However, when the data were stratified by the sex of the adult household members, we found associations between the number of diapers changed and infection. Among women, those who changed a greater number of diapers were more likely to be infected than those who changed fewer diapers. Yet, surprisingly, we found that the opposite was true for men; men who changed a greater number of diapers were significantly less likely to be infected than those who changed fewer diapers.

These findings were explained by differences in consistency of handwashing after diaper changing among men and women. There was a trend toward less regular handwashing among women who changed a greater number of diapers than among those who changed fewer diapers (although the difference between the groups in handwashing practices was not significant). In contrast, a higher percentage of men who changed ≥ 90 diapers per month than of men who changed fewer diapers reported always washing their hands after changing diapers (although again the difference was not significant). Among those who changed ≥ 90 diapers per month, men were significantly more likely than women to report always washing their hands after diaper changing. Although the men in this study who changed ≥ 90 diapers had a high potential for infection through exposure to E30 in fecal material of their infected children, they protected themselves by appropriate handwashing and were less infected than men who changed fewer diapers.

One finding that differed from those of the previous study was the rate of infection among center staff, 47% in the present study compared with 14% in the earlier study.[4] A possible explanation is a difference in handwashing by staff at the two child care centers. While we noted inconsistent handwashing among staff after diaper changing, the investigators of the prior study observed excellent hygiene among staff.

Limitations. The finding of a difference in rates of meningitis among adults and children with E30 infection may not be meaningful because headache is not reliably reported by young children. However, we also assessed the more objective symptoms of vomiting and fever as well as frequency of hospitalization and found more prolonged illness among adults and no hospitalizations among children. Although the rates of meningitis for adults and children may not be comparable, infected adults clearly had more severe illnesses than infected children.

One limitation of our serologic survey is that the IgM test is not 100% sensitive or specific. One of 17 tested adults with clinical viral meningitis had a negative IgM test. This could have been due to the 95% sensitivity of the test, infection with an enterovirus other than E30, or to the problems inherent in our definition of viral meningitis, which was based on report of symptoms by the patient. However, misclassification with a test that is only 95% sensitive (5% of infected people are misclassified as uninfected) would not differ across risk groups, and associations between infection and risk factors (for example, handwashing) would be biased toward the null.[8]

The 95% sensitivity may also explain why five adult household members with recent infections had children with no evidence of recent infection. Alternatively, the lack of 100% specificity may have resulted in misclassification of these five adults as positive. In either case, these five results represented only 4% of the adult household members tested, indicating the small magnitude of any misclassification error.

Those who said they always washed their hands after changing diapers had a lower rate of infection than those who reported washing their hands less regularly.

Implications. This is the second documentation of an E30 outbreak in a child care center identified through a cluster of viral meningitis among parents of children attending the center. This observation is analogous to the identification of hepatitis A outbreaks in child care centers through illness among parents or staff associated with the centers.[9] Because adults infected with the hepatitis A virus get the disease at a much higher rate than infected children, outbreaks of hepatitis A infections in child care centers are detected through hepatitis cases in adult household members and staff.

The Centers for Disease Control and Prevention recommend that local health departments query adults with hepatitis A about the location of their children's day care so that outbreaks can be rapidly identified and halted.[10] Similarly, outbreaks of enteroviruses might be uncovered if adults with viral meningitis were routinely questioned by health departments about their children's day care or preschool or if child care directors reported clusters of cases among parents of children attending their facilities.

Although prevention of transmission of enteroviruses among children within a child care facility may be very difficult, parents and staff in these settings should be advised that they can protect themselves by washing their hands after exposure to stool or saliva.[11] In addition to continuing efforts to improve hygiene within child care settings, adult household members should be educated about disease transmission and the benefits of appropriate handwashing before eating and preparing food, after changing diapers or using the toilet, and after returning home from a child care facility.

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