INTRODUCTION

Sociocultural changes that have occurred in the United States during the past several decades have resulted in an increasing demand for out-of-home child care. Demand for group child care has increased markedly in proportion to the number of mothers with young children employed outside the home. As society has become increasingly mobile, with fewer extended families living in close proximity to one another, many working mothers cannot rely on relatives to provide child care. In the United States, the proportion of employed mothers using child care more than doubled from 1965 to 1990. In 1990, the National Child Care Survey showed that 40 percent of mothers whose youngest child was under 1 year of age, and 52 percent of mothers whose youngest child was 1–2 years of age, worked either part- or full-time, and the proportion of working mothers further increased as the age of the youngest child increased (1).

The increased use of child care has had a significant impact on the epidemiology and cost to society of infectious diseases in the United States, since child-care settings are associated with outbreaks of illness, and attendees have more frequent infectious illnesses, more severe illnesses, and receive more antimicrobial agents than children cared for at home. Child-care providers, families of children who attend group child care, and other close contacts also are at increased risk of infectious diseases associated with child-care environments. Child-care settings are fertile environments for the transmission of disease-causing organisms because young children who lack appropriate hygienic behavior and who are naive immunologically are grouped together in close proximity. The risk of infectious diseases among children in child-care facilities is dependent, in part, on characteristics of the child (including age, sex, immune status, and recent enrollment in a new child-care setting) as well as characteristics of the child-care environment. There are various types of child-care settings, including family child-care homes, group homes, and child-care centers. Risk of infection may differ by type of setting, size of the child-care group or facility, and hygienic policies and practices of the child-care facility.

The high prevalence of infectious illnesses in the child-care setting combined with increased use of antimicrobial agents has resulted in the emergence of antibiotic-resistant organisms. These organisms are spread readily among children and care providers as a result of crowding, the need for hands-on care of children, environmental contamination, and breakdown in appropriate hygiene, especially handwashing.

This presentation reviews data published in the following areas: types of child-care arrangements in general use in the United States, infectious diseases associated with child care, use of antibiotics and emerging antibiotic-resistant organisms associated with child care, the potential for transmission of blood-borne pathogens in child-care settings, and the cost associated with illness among children in child-care settings. Strategies to prevent and control transmission of infectious diseases in child-care settings also are discussed. Data sources for this review included a MEDLINE search from 1980 of articles published in English, references identified from bibliographies of pertinent articles and books, and databases of the authors.

TYPES OF CHILD CARE

As many as 10 million children aged 5 years and younger attend various types of regulated and unregulated child-care facilities in the United States (1). Several types of out-of-home child-care facilities have been defined according to their location and number of children enrolled (2). Family child care homes include
sites with fewer than six children in the residence of the care provider. Group homes include 6–12 children usually cared for by more than one care provider in a residence of one of the care providers. Child-care centers have more than 12 children enrolled and usually place children in separate groups according to age and/or developmental level. Preschool child-care programs, usually designed for children aged 3 and 4 years, may be part of a child-care center, part of a school for older children, or may be freestanding. The majority of children in child care are cared for in child-care homes. Center care is used by more children aged 3–4 years compared with children under 3 years of age (approximately 65 percent and 25 percent, respectively) (1).

**INFECTIOUS DISEASES ASSOCIATED WITH CHILD CARE**

Children who attend out-of-home child care are at increased risk for infectious diseases (table 1) (3–9). Respiratory tract and gastrointestinal tract infections are the most common infections that occur among children in child-care settings. Other infections which have been associated with child care include hepatitis A virus, invasive bacterial diseases due to *Haemophilus influenzae* type b and *Streptococcus pneumoniae*, cytomegalovirus, and varicella zoster virus. Several other conditions have a probable association. Child-care providers and household contacts of children in child care also are at increased risk for many of these illnesses (10–13).

**Respiratory tract infections**

Respiratory tract infections, including otitis media, pharyngitis, sinusitis, bronchitis, bronchiolitis, and pneumonia, account for the majority of disease episodes that occur in child-care settings (14). Organisms that are responsible for infectious illnesses in children in child care are similar to those associated with illnesses in children who do not attend child care. Children who attend child care have more frequent and more severe episodes of respiratory tract disease (14–17).

**Upper respiratory tract.** In a prospective cohort study (15), 89 percent of disease episodes among children attending a child-care center were respiratory tract infections. During the first year of study, significantly higher proportions of children in group care (52 percent) or in child-care centers (67 percent) experienced more than 60 days of respiratory tract illness than children cared for at home (16 percent); findings

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<table>
<thead>
<tr>
<th>Type of disease or infection</th>
<th>Examples</th>
<th>Increased incidence with child care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteric infection</td>
<td>Diarrhea</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Hepatitis A</td>
<td>Yes</td>
</tr>
<tr>
<td>Respiratory tract infection</td>
<td>Otitis media</td>
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</tr>
<tr>
<td></td>
<td>Pharyngitis</td>
<td>Probably</td>
</tr>
<tr>
<td></td>
<td>Sinusitis</td>
<td>Probably</td>
</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td>Probably</td>
</tr>
<tr>
<td>Invasive bacterial disease</td>
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<tr>
<td></td>
<td><em>Neisseria meningitidis</em></td>
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<td></td>
<td><em>Streptococcus pneumoniae</em></td>
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<tr>
<td>Aseptic meningitis</td>
<td>Enteroviruses</td>
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</tr>
<tr>
<td>Herpesvirus infection</td>
<td>Cytomegalovirus</td>
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</tr>
<tr>
<td></td>
<td>Varicella zoster</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Herpes simplex</td>
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</tr>
<tr>
<td>Blood-borne diseases</td>
<td>Hepatitis B</td>
<td>Few case reports</td>
</tr>
<tr>
<td></td>
<td>Human immunodeficiency virus</td>
<td>No cases reported</td>
</tr>
<tr>
<td>Vaccine-preventable diseases</td>
<td>Measles, mumps, rubella, diphtheria, pertussis, tetanus</td>
<td>Not established</td>
</tr>
<tr>
<td></td>
<td>Polio</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td><em>H. influenzae</em> type b</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Hepatitis B</td>
<td>Few case reports</td>
</tr>
<tr>
<td></td>
<td>Varicella zoster</td>
<td>Yes</td>
</tr>
<tr>
<td>Skin disease</td>
<td>Impetigo</td>
<td>Probably</td>
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<tr>
<td></td>
<td>Scabies</td>
<td>Probably</td>
</tr>
<tr>
<td></td>
<td>Pediculosis</td>
<td>Probably</td>
</tr>
<tr>
<td></td>
<td>Ringworm</td>
<td>Probably</td>
</tr>
</tbody>
</table>
were similar for the second year of study (centers, 59 percent; group care, 50 percent; home care, 20 percent) (16). During the third year of study, the proportions of children with more than 60 days of respiratory tract illness decreased in child-care centers (36 percent) and in group care (27 percent), while the corresponding proportion cared for at home remained stable (16 percent). The associations between severe illness and type of child care for each year were similar to the associations for frequency of respiratory tract illness and type of child care.

In a cross-sectional survey of households in Atlanta, Georgia, 24 percent of children aged less than 5 years developed upper respiratory tract illness (18). Children who attended child care were at increased risk of upper respiratory tract illness compared with children who did not attend child care (odds ratio (OR) = 1.6, \( p = 0.02 \)). After adjusting for other risk factors, approximately one-third of upper respiratory tract infections experienced by children in child care were attributable to child-care exposure. An estimated population risk of 10 percent attributable to child-care exposure was based on the attributable risk found in the sample of children attending child care and the proportion of children in the general population who attend child care. Results from a nationwide survey showed that when children aged 18–35 months were stratified according to having an older sibling, child-care exposure was only a significant risk factor for respiratory tract illness among children who did not have an older sibling (OR = 3.4, 95 percent confidence interval (CI) 2.0–6.0; and OR = 1.0, 95 percent CI 0.65–1.6, respectively) (19).

**Otitis media.** Child care is a well recognized risk factor for otitis media (20). Studies in various countries in Europe and in the United States (21–23) have found similar risks associated with child care attendance (table 2). Risk has been shown to be greater for children who spend at least 20 hours per week in child care (24). A survey in Atlanta showed an increased risk for otitis media associated with full-time child-care attendance (≥40 hours per week) (OR = 3.2, \( p = 0.005 \)) (18). After adjusting for other risk factors, approximately two-thirds of the risk was attributable to full-time child-care attendance. The estimated population risk for otitis media attributable to full-time child-care exposure was 12 percent.

A study using the Child Health Supplement of the 1988 National Health Interview Survey, a nationwide, population-based household survey on health status information that is conducted annually by the National Center of Health Statistics of the Centers for Disease Control and Prevention (CDC), showed that, for children younger than 12 months of age, size of the group in which the child is cared for is an important risk factor for otitis media (23). Within the child-care setting, risk for otitis media increased with increasing group size. These findings support those from an earlier cohort study conducted among children receiving medical care in a prepaid health care plan in 1985–1986 which indicated that the number of children in the room was the strongest predictor of otitis media (25).

**Group A streptococcus.** Group A \( \beta \)-hemolytic streptococcus is a relatively common cause of pharyngitis in children. In one study, group A \( \beta \)-hemolytic streptococcus was isolated from the throats of 37 percent of children under 3 years of age presenting with signs or symptoms of pharyngitis (26). During the last 15 years, the incidence of invasive group A \( \beta \)-hemolytic streptococcus disease has increased among children and adults in the United States and in other countries (27, 28), including reports involving children in group child care. In Israel, the prevalence of group A \( \beta \)-hemolytic streptococcus was 2.7 percent among infants and 8.4 percent among toddlers attending 10 child-care centers (29). These rates rose in midwinter to 8.5 percent for infants and 17.8 percent for toddlers. Except for rhinitis in the spring and summer months, carriage of group A \( \beta \)-hemolytic streptococcus was not associated with respiratory tract symptoms.

Outbreaks of group A \( \beta \)-hemolytic streptococcus infections have occurred in child-care settings (30, 31). An investigation following a fatal case of invasive serotype T-1 group A \( \beta \)-hemolytic streptococcus disease in a child-care center presented results of testing 87 percent of the children in the center and found 25 percent positive for group A \( \beta \)-hemolytic streptococcus; overall prevalence for T-1 group A \( \beta \)-hemolytic streptococcus was 18 percent (32). Increased time per week in the child-care center was a risk factor for carriage of the T-1 group A \( \beta \)-hemolytic streptococcus (OR = 1.03, 95 percent CI 1.00–1.06), and antibiotic use in the preceding 4 weeks was protective (OR = 0.2, 95 percent CI 0.1–0.9). There was a trend for

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**TABLE 2.** Relative risks (RR) or odds ratios (OR) for otitis media associated with child-care centers*

<table>
<thead>
<tr>
<th>Study location (reference no.)</th>
<th>Study design</th>
<th>Age (months)</th>
<th>RR or OR</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden (21)</td>
<td>Cohort</td>
<td>6–17</td>
<td>3.6</td>
<td>1.3–10.1</td>
</tr>
<tr>
<td>Finland (22)</td>
<td>Cohort</td>
<td>12</td>
<td>2.0</td>
<td>1.6–2.5</td>
</tr>
<tr>
<td>United States (23)</td>
<td>Cross-sectional</td>
<td>&lt;24</td>
<td>2.3</td>
<td>1.8–2.9</td>
</tr>
</tbody>
</table>

* RR or OR refer to child-care centers versus home care.
increased risk of T-1 group A β-hemolytic streptococcus carriage among children cared for in the same room as the index case compared with children in other rooms (OR = 2.7, 95 percent CI 0.8–9.4). A case-control study of children with varicella who developed invasive group A β-hemolytic streptococcus disease found an increased risk for invasive group A β-hemolytic streptococcal disease among children cared for at home compared with those in out-of-home child care (OR = 4.4, 95 percent CI 1.1–15) (33). The decreased risk found for child-care attendance may have been related to characteristics of the children with varicella who may have been more likely to have been cared for at home, such as children who had asthma or who were taking albuterol and were at higher risk for group A β-hemolytic streptococcal disease (OR = 6.2, 95 percent CI 1.2–41; and OR = 11.6, 95 percent CI 1.0–581, respectively).

In summary, the high prevalence of child-care attendance together with increased transmission of disease-causing organisms in child-care settings has a profound effect on the epidemiology of respiratory tract illness in children. Child-care attendance is an important risk factor for upper respiratory tract infections.

Invasive bacterial disease

Children also may develop severe, life-threatening invasive diseases through respiratory transmission of bacteria such as H. influenzae type b, S. pneumoniae, and Neisseria meningitidis. The availability and wide use of highly effective H. influenzae type b conjugate vaccines in young children has reduced markedly the incidence of invasive H. influenzae type b disease, including meningitis. In the pre-vaccine era, child-care attendance was an important risk factor for H. influenzae type b meningitis (34–39). In a pre-vaccine population-based matched case-control study conducted in Oklahoma between 1986 and 1987, the risk for H. influenzae type b meningitis increased as the number of hours per week in child care and the number of children per child-care room increased (>30 hours per week and >4 children per room, OR = 10.6, 95 percent CI 5.3–21), compared with any child care (OR = 5.1, 95 percent CI 3.1–8.2) (40).

S. pneumoniae is presently the leading cause of invasive bacterial disease in young children. Each year approximately 160 per 100,000 children aged 2 years and under develop bacteremia caused by S. pneumoniae (41). Child-care attendance has been associated with a higher incidence of primary invasive disease caused by S. pneumoniae (42, 43) (table 3). Child-care contacts of cases of S. pneumoniae in child-care settings frequently are colonized with the organism (44–46). In one report, type 12F S. pneumoniae was isolated from four of six ill children in a family child-care home, three of whom had a febrile illness and bacteremia and one of whom had purulent conjunctivitis (46). The two remaining well children were colonized with type 12F S. pneumoniae.

Enteric disease

Diarrhea is the second most common disease among children in child-care facilities (6, 7, 47–50). A longitudinal study conducted in 13 child-care centers in Houston, Texas, found an incidence of acute diarrhea of 2.6 cases per year among children under 3 years of age (7, 51). Most diarrheal illness that occurs in child care is of mild to moderate severity, but many cases result in physician office visits. A study conducted in a health maintenance organization in Houston found that 19 percent of office visits for acute diarrhea among children under 3 years of age were attributable to child-care attendance (49).

Outbreaks. Episodes of acute infectious diarrhea in child-care settings that occur in outbreaks have been associated with a number of bacterial, viral, and parasitic enteropathogens, including Aeromonas, astrovirus, calicivirus, enteric adenovirus, hepatitis A virus, rotavirus, Cryptosporidium, Giardia lamblia, toxigenic Clostridium difficile, Escherichia coli strains including O157:H7, Campylobacter upsaliensis, and Shigella (6, 8, 52–59). Rotavirus is the most commonly identified enteropathogen associated with outbreaks of diarrhea in child-care settings, accounting for one-quarter of identified outbreaks. A 1-year study of eight child-care centers in the Norfolk, Virginia, area identified 15 outbreaks of diarrhea (57). Rotavirus, enteric adenovirus, and/or astrovirus were associated with half of the outbreaks that occurred. Multiple enteropathogens have been identified in many of the outbreaks of diarrhea in child-care settings (58).

Outbreaks of diarrheal illness caused by bacterial enteropathogens, although less commonly reported than outbreaks caused by viruses, can have serious impact, especially those due to antibiotic-resistant Shigella and E. coli O157:H7. An outbreak of Shigella...
sonnei infection that involved 14 licensed child-care centers was reported in Lexington-Fayette County, Kentucky (59). Child-care centers involved in the outbreak were more likely than matched control centers to have a food handler who changed diapers. There were a total of 219 culture-confirmed cases of shigellosis identified in this 5-month community-wide epidemic, of which 47 percent were associated with group child care. Among children under 6 years of age, 92 percent of identified cases were associated with severe disease, including hemolytic uremic syndrome (54, 55). In one study, 36 (34 percent) of 107 children in a child-care center had diarrhea associated with E. coli O157:H7 (54). Illness was significantly more frequent in children younger than 4 years of age when compared with older children (relative risk (RR) = 4.0, p < 0.001). Three of the 36 children developed hemolytic uremic syndrome. In another study, 29 of 68 cases of E. coli O157:H7 infection identified in Minnesota during an 18-month period were identified at nine child-care centers (55). The median attack rate at these nine centers was 22 percent.

Transmission. The major route of transmission of organisms causing gastrointestinal illnesses in child-care settings is person-to-person via the fecal-oral route (6); food-borne outbreaks of diarrhea are uncommon. In 1993, an outbreak of gastrointestinal illness caused by Bacillus cereus occurred among children and staff at two jointly owned child-care centers (60). Cases were reported in 12 children and two staff members who had eaten chicken fried rice that had been cooked in the morning, held without refrigeration, and served at lunch without reheating.

Asymptomatic excretion. In addition to causing diarrheal illness, enteropathogens also are excreted asymptotically by children in child care (58, 61–64). Asymptomatic excretion of enteric viruses (57, 58, 61, 63) and G. lamblia (64–66) occurs frequently, even during outbreaks of diarrhea in child-care facilities. In a longitudinal study of 82 children under 2 years of age attending child-care centers, one-third of the children became infected with G. lamblia, and 78 percent of those infected were asymptomatic (64). Children excreted G. lamblia for a mean 2.1 (± 1.5) weeks. Of the children under study, 45 percent became infected with rotavirus; half of the infections were asymptomatic.

Risk factors. Studies comparing different types of child-care settings have found that there is a 2.2- to 3.5-fold increased relative risk of diarrhea among children under 3 years of age associated with attendance in child-care centers compared with children cared for at home (49, 67, 68) (table 4). Findings regarding the risk of diarrheal illness among children attending child-care homes have been variable. In one study, the relative risk of diarrheal illness in child-care homes was twice that of home care (RR = 2.0, 95 percent CI 1.3–3.1) (49), whereas in other studies, no difference in risk was noted for children in child-care homes compared with children cared for at home (67, 68).

Characteristics of children in child care, including length of time since enrollment, age, sex, and immunologic status, are associated with risk of illness. New enrollees in child-care settings have been found to have a higher risk for diarrhea than other children in the same settings. Two studies reported that the relative risk of acute diarrhea was 1.6-fold greater among young children recently enrolled in a child-care facility compared with children who had been in attendance in the same facility longer than 4 weeks (49, 69).

Risk of diarrhea among children attending child care is significantly greater among infants and toddlers in diapers than for older, non-diapered children (70). In one longitudinal study of 12 child-care centers, the incidence of diarrhea among infants was reported to be 3.6 cases per child per year, declining to 1.3 cases per child per year among children aged 18 months and older (69). When infants and young toddlers are grouped together, their continuous exploration of the environment, increased contact with feces prior to toilet training, frequency with which they put their hands and other objects into their mouths, and need for hands-on contact by care providers contribute to the transmission of enteropathogens. In addition, diarrhea has been found to occur more frequently in male than

### TABLE 4. Relative risks (RR) or odds ratios (OR) for diarrhea by type of child care

<table>
<thead>
<tr>
<th>Study (reference no.)</th>
<th>Study design</th>
<th>Type of child care setting</th>
<th>Center</th>
<th>Home</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>RR or OR</td>
<td>95% confidence interval</td>
<td>RR or OR</td>
</tr>
<tr>
<td>Bartlett et al. (68)</td>
<td>Cohort</td>
<td>2.2</td>
<td>1.3–3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Alexander et al. (67)</td>
<td>Case-control</td>
<td>3.5</td>
<td>1.0–4.8</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Reves et al. (49)</td>
<td>Case-control</td>
<td>2.4</td>
<td>1.6–3.7</td>
<td>2.0</td>
</tr>
</tbody>
</table>

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in female children in child-care centers (69).

**Environmental factors.** Environmental contamination in child-care settings is common as determined from detection of rotoviruses (71, 72), *Giardia* cysts (73), hepatitis A virus (74), and fecal coliform bacteria on surfaces and on hands of children and care providers (75–78). In a study of five child-care centers, fecal coliform bacteria were isolated from classroom objects in 17 percent of samples and from hands in 12 percent of samples obtained (76). During outbreaks of diarrhea in these same centers, the rates of isolation rose to 38 percent for classroom objects and 32 percent for hands. The occurrence of diarrhea in child-care centers has been shown to be associated with an increased contamination of children’s and providers’ hands, and the contamination of children’s hands is associated with an increased contamination of environmental surfaces (75).

Child-care practices have been shown to be associated with degree of environmental contamination. For example, less fecal coliform contamination was found on hands and environmental surfaces in child-care centers where children wore clothes over diapers compared with centers where children did not wear clothes over diapers, and where children wore paper diapers compared with cloth diapers (76, 79). Another study that used artificial feces with either carbon black or fluorescein dye added to measure containment by single-use paper diapers and cloth diapers found better containment by single-use paper diapers compared with cloth diapers (80). This study also showed that vinyl pants used over diapers were a source of contamination for caretakers’ hands and the environment. In another study, paper diapers did not decrease environmental contamination when compared with front closure cloth diapers with waterproof covers which, when soiled, were put unrinsed in sealable plastic containers and washed by a diaper service (78).

**Transmission in families and to child-care workers.** Transmission of enteropathogens is increased not only among children who attend child care, but also among their family members and child-care workers. In a prospective study of diarrhea in 20 child-care centers, 34 (10 percent) of 331 family contacts of children with diarrhea developed diarrhea (65). Secondary attack rates were 26 percent for *Shigella*, 15 percent for rotavirus, and 17 percent for *G. lamblia*. Secondary cases could not be attributed to higher household density or to the proportion of adults in the household. During an outbreak of diarrhea due to *E. coli* O157:H7 in a child-care center, 10 (18 percent) of 56 family members of ill children but only 1 of 45 family members of well children younger than age 4 years developed a diarrhea episode, and *E. coli* O157:H7 was identified in stool specimens from four children (54). *Cryptosporidium* is a common cause of diarrhea in children occurring sporadically and in outbreaks in child-care settings, and also is frequently transmitted to child-care providers and household contacts (53). In another study of outbreaks of diarrhea in child-care centers, 40 percent of care providers developed diarrhea (70). A study that evaluated illness in child-care workers showed that they had a significantly higher risk of at least one infectious disease and lost more work days because of infectious diseases compared with other employed women of comparable ages (13).

Outbreaks of enterovirus illness in child-care settings are likely to remain unnoticed because most enterovirus infections are mild or asymptomatic. The results of an investigation of an echovirus 30 outbreak, which was undertaken following hospitalization for aseptic meningitis of seven parents of children in a child-care center, showed that 75 percent of the children, 60 percent of parents, and 14 percent of teachers were infected (81). A total of 12 parents and two children (one hospitalized) developed aseptic meningitis. The low infection rate among teachers was attributed to their more frequent handwashing after changing diapers, wiping children’s noses, and before eating compared with mothers of the children. Furthermore, mothers who became seropositive were less likely than seronegative mothers to report handwashing following changing diapers.

In summary, attendance at child-care centers compared with home care has been shown to increase the risk of acute diarrheal disease at least twofold because of infections which may be caused by a variety of enteropathogens. Increased risk is not as clearly established for children enrolled in family child-care homes. Risk of diarrheal illness is increased for children recently enrolled in a child-care facility, children in diapers, and males. Fecal contamination of the environment of children in diapers is common and appears to contribute to outbreaks of diarrheal illness among children, their care providers, and families.

**Hepatitis A virus**

Transmission of hepatitis A virus is primarily through the fecal-oral route, most often by close person-to-person contact, and is more likely to occur among children under 3 years of age. In an experimental study, 16–30 percent of hepatitis A virus which was recoverable at the time that the virus was placed on the hands of volunteers was detectable on their finger pads after 16 hours, and hepatitis A virus was transferred to clean surfaces touched by the volunteers (74). During the last 20 years, outbreaks of hepatitis A virus in child-care centers have been re-
ported throughout the United States and have been shown to serve as the source of community-wide outbreaks (82). Infection in young children usually is asymptomatic or mild and nonspecific. Seroprevalence studies following outbreaks in two child-care centers showed that although only 1.5 and 8.2 percent of children had clinical hepatitis, 53 and 44 percent, respectively, were seropositive for anti-hepatitis A virus (83). Because of the low rate of clinical symptoms among young children, and because infectivity is greatest during the 2 weeks prior to onset of symptoms, outbreaks usually are not recognized until infection has spread to adult contacts. In a series of outbreaks in child-care centers in Louisiana and Arizona, 70–85 percent of cases occurred among parents, 15 percent occurred among child-care center employees, and 5 to 15 percent occurred among attending children (83, 84). In an outbreak in Oklahoma, all cases were among adults (85). An investigation of a county-wide outbreak in Florida showed that 37 percent of cases were linked to child-care centers (86). Approximately 15 percent of reported cases of hepatitis A virus in the United States are related to child care (87).

Other infectious diseases

Varicella. Varicella spreads readily when groups of susceptible children are in close proximity for extended periods of time. Data from the National Health Interview Survey from 1980 to 1990 show that most cases (44 percent) occurred in children 5–9 years of age, followed by cases among children 1–4 years of age (33 percent) (88). In the past, 50–60 percent of cases of varicella occurred in school-age children (89, 90), and cases of varicella in preschool-age children occurred mostly in children following exposure to infected school-age siblings. During the past several decades, the incidence of varicella among preschool-age children has been increasing. A survey in seven child-care centers in North Carolina showed that varicella occurred at a mean age of 25 months among children in child care, and prevalence was 71 percent by the time children reached 5 years of age (91). There was a trend toward higher risk among children attending a large center (187 children) compared with those attending a smaller center (71 children) (OR = 0.73, 95 percent CI 0.05–0.6; p = 0.06). Although varicella generally is mild in young children, transmission may occur to susceptible adolescents and adults or to immunocompromised persons of all ages who are at risk for more severe disease and complications. Pregnant women also are at risk for severe disease, and there is a 2 percent risk of congenital abnormalities in infants whose mothers are infected during the first half of their pregnancies (92, 93).

Cytomegalovirus. In the past, cytomegalovirus infection was associated with low socioeconomic status, occurring predominantly among impoverished populations. The high prevalence of child-care usage has changed the epidemiology of cytomegalovirus infection in that it now affects persons in all socioeconomic strata, especially working mothers with children in child care. Up to 70 percent of children in child-care centers shed cytomegalovirus in urine and saliva, and most children shed cytomegalovirus for at least 24 months after a primary infection (94). However, since infection with cytomegalovirus is inapparent in 99 percent of cases, it does not pose a direct problem to other children or to most adults. The importance of the high incidence of cytomegalovirus infection in child-care settings is the risk of transmission to a susceptible pregnant woman during the first half of their pregnancies. Approximately 40 percent of mothers infected during pregnancy transmit cytomegalovirus transplacentally to the fetus. Congenital cytomegalovirus disease is the major cause of severe multiple birth defects in the United States, causing severe defects in about 10 percent of infected neonates; an additional 5–17 percent of infants asymptomatic at birth develop sensorineural hearing loss or other neurologic defects (95).

Seroconversion rates for cytomegalovirus among mothers of children in child care and among child-care providers are 2- to 15-fold higher than seroconversion rates observed among hospital employees (table 5) (96–99). Annual seroconversion rates in mothers of infected children far exceed those in mothers of uninfected children (30 percent versus 3 percent, respectively (RR = 10.2, 95 percent CI 2.4–43.8)) (96). Similarly, child-care workers who care for children younger than 2 years of age have been shown to have a higher seropositivity rate (46 percent) than those who care for children older than age 2 years (35 percent) (RR = 1.3, 95 percent CI 1.05–1.6) (97). In other studies, 8–20 percent of seronegative child-care workers who cared for children younger than 3 years of age for a minimum of 20 hours per week serocon-

<table>
<thead>
<tr>
<th>Group</th>
<th>No. seronegative</th>
<th>Annual seroconversion rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child-care provider</td>
<td>202</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>82</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>82</td>
<td>8</td>
</tr>
<tr>
<td>Hospital employees</td>
<td>229</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>2</td>
</tr>
<tr>
<td>Mothers</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

*References: Adler (96, 97), Pass et al. (98), and Murph et al. (99).
In summary, exposure to varicella zoster virus and cytomegalovirus in child-care settings represents a significant source of transmission among preschool-age children and their close contacts, and transmission is associated with significant health risks. Although there is increased risk of exposure to parvovirus B19 present in child-care settings, it is important only to pregnant women, and consequences to the fetus are relatively uncommon.

ANTIBiotic USE

Data from the National Ambulatory Medical Care Survey conducted by the National Center for Health Statistics, CDC, showed a 28 percent increase in antimicrobial therapy prescribed by office-based physicians between 1980 and 1992 (104). The rate of antibiotic use among children younger than 15 years of age was approximately threefold higher than that observed among older age groups. Respiratory tract illnesses, which are common in the pediatric age group, including otitis media, upper respiratory tract infection, bronchitis, sinusitis, and pharyngitis, were the leading diagnoses associated with antibiotic use in persons of all ages. In the last three National Ambulatory Medical Care Surveys (1985, 1989, 1992), otitis media accounted for over 40 percent of outpatient antimicrobial use in children (105). Data from the National Health Interview Survey showed that between 1982 and 1991, the incidence of otitis media among children younger than 5 years of age increased by 64 percent.

Antibiotics are often misused in managing upper respiratory tract infections and diarrheal illnesses. The majority of upper respiratory tract infections are of viral etiology, yet antibiotics are prescribed frequently, with no impact on illness. Similarly, most episodes of diarrhea are caused by viruses and, therefore, do not require or benefit from antibiotic treatment. In one study, 40 percent of children treated for diarrhea in the office setting by pediatricians affiliated with a pediatric teaching hospital were given antibiotics (106). Another inappropriate use of antibiotics is the use of broad-spectrum antibiotics to treat conditions that do not warrant their use. Recently marketed antibiotics, such as cephalosporins, have a broader spectrum of action or contain additional compounds that extend the spectrum of the previously used antibiotic, such as in ampicillin-sulbactam. Although such compounds have been developed in response to resistance, their use may promote development of resistance. During 1993 and 1994, 24 percent and 17 percent, respectively, of children receiving care in two large health maintenance organizations were given cephalosporins or combination agents for otitis media (107).
Child care and antibiotic use

Several studies have demonstrated that children in child-care centers are given antibiotics more frequently than children cared for at home (108–110) and children in child-care homes (108, 111, 112). In one study, 270 children less than 3 years of age receiving care at a health maintenance organization were monitored for an 8-week period. Antibiotic use in these children differed according to the type of child-care arrangement (table 6) (109). Over the 8-week period, 36 percent of children in child-care centers received antibiotics compared with 7 percent of children in child-care homes and 8 percent of children cared for at home. The estimated annual rate of antibiotic use was 3.6-fold higher for children attending child-care centers compared with children in child-care homes or children cared for in their own homes (p < 0.001). Children attending child-care centers constituted only 16 percent of the clinic population but accounted for 45 percent of the days of antibiotics prescribed. No association was found between types of antibiotics prescribed and mode of care; however, the mean duration of administration was 19.5 days for children attending child-care centers, which was five times longer than that for children in home care (p < 0.001).

EMERGING ANTIBIOTIC RESISTANCE

The emergence of antibiotic-resistant organisms is increasing the potential for poor outcomes of common infectious diseases and is a serious problem worldwide. During the past decade, antibiotic-resistant organisms have been identified with increasing frequency in the United States (113, 114). Widespread antimicrobial use is a major risk factor for acquisition of antibiotic-resistant infections in children (44, 45, 115–119). The Task Force on Antibiotic Resistance of the American Society for Microbiology reported that, as infectious organisms acquire resistance to an increasing number of antimicrobial agents, the prospect becomes more likely that infections will occur that cannot be treated effectively by any of the available antimicrobial agents (107).

| Table 6. Days of antimicrobial agents prescribed to children under 3 years of age by type of child care during an 8-week period of study* |
|---|---|---|
| Child care | No. | % receiving antibiotics | Mean no. of days of antibiotic use |
| Child-care center | 43 | 36 | 19.5 |
| Child-care home | 72 | 7 | 4.0 |
| Home care | 156 | 8 | 4.6 |
* Reference: Reves and Jones (108).

The emergence of antibiotic-resistant *S. pneumoniae* in young children is particularly disturbing, because *S. pneumoniae* is identified in up to 50 percent of episodes of otitis media (120) and is the most common cause of serious invasive bacterial infections in children (42, 121). Results of national surveillance among 30 centers conducted during the winter of 1994/1995 showed that, overall, 24 percent of *S. pneumoniae* strains were not susceptible to penicillin, with 14 percent intermediate and 10 percent high-level resistant (119). Pneumococcal isolates that are highly resistant to penicillin frequently are resistant to a variety of other antimicrobial agents, including cephalosporins, trimethoprim-sulfamethoxazole (TMP/SMX), erythromycin, chloramphenicol, and tetracycline (113).

Child care and antibiotic resistance

An increased prevalence of antibiotic-resistant organisms among children attending child care compared with children cared for at home may be expected considering the more frequent use of antibiotics, the gathering of large numbers of susceptible children, and the increased prevalence of infectious diseases in child-care settings. Resistant strains of bacteria have been identified in child-care-associated outbreaks of disease caused by *S. pneumoniae* (43, 44, 122) and *Shigella sonnei* (123–125). High rates of colonization with antibiotic-resistant *S. pneumoniae* (45, 116), *H. influenzae* (126), and *E. coli* (108, 109, 127) also have been found among children in child-care centers.

An investigation in 1988 following two cases of invasive disease from a single child-care center in Texas identified *S. pneumoniae* in 35 percent of nasopharyngeal cultures from children enrolled in that center, of which 34 percent were resistant to multiple antibiotics (44). A follow-up study conducted in 1989 among 140 children less than 3 years of age attending four child-care centers in Texas found nasal carriage of *S. pneumoniae* in 39 percent of children and intermediate resistant *S. pneumoniae* in 4 percent. Among the resistant strains, 62 percent were resistant to multiple antibiotics (128).

More recent studies have found higher rates of antibiotic-resistant *S. pneumoniae*, suggesting that antibiotic resistance among children may be escalating. A study conducted in Kentucky in 1993 found high rates of antibiotic-resistant *S. pneumoniae* both in children who attended child care (59 percent) and in children who did not attend child care (32 percent) (129). Significant risk factors identified by multivariate analysis included child-care attendance, current acute otitis media, and increased antimicrobial use during the preceding 6 months.
Another study conducted in Omaha, Nebraska, in 1994 demonstrated a marked seasonal variation in antibiotic-resistant \textit{S. pneumoniae} (130). In April, 59 percent of 54 children attending a child-care center were colonized with \textit{S. pneumoniae}, 33 percent of isolates were intermediate resistant, and 53 percent of isolates were highly resistant to penicillin. Although a similar proportion (54 percent) of children were colonized with \textit{S. pneumoniae} 4 months later, and a similar proportion of isolates were intermediate resistant to penicillin (39 percent), only 7 percent of isolates were highly resistant. Antibiotic use among children attending the child-care center decreased considerably between the two sampling periods. The authors considered the increased use of antibiotics in the closed environment of the child-care center during the late winter a cofactor in producing the elevated prevalence of highly resistant \textit{S. pneumoniae} found in the spring compared with that found in late summer.

Carriage of resistant strains of \textit{S. pneumoniae} appears to cluster and persist in some child-care centers. In a child-care center in which multiply resistant \textit{S. pneumoniae} was isolated from middle ear fluid of a child with otitis media, 21 percent of the children were identified as carriers of resistant bacteria (45). However, no carriers were identified among children attending two other child-care centers in the same community. Among children in the index center, risk of carrying multiply resistant strains of \textit{S. pneumoniae} was related directly to receipt of antibiotic therapy in the previous 3 months. Several studies have shown that the most consistently identified risk factor associated with penicillin-resistant \textit{S. pneumoniae} is recent use of an antimicrobial agent for therapy or prophylaxis (45, 118, 128-130). Therefore, any child who has received a course of antibiotics within the preceding month or who has been in a setting, such as child care, where antimicrobial use is common, should be considered at increased risk for carrying a penicillin-resistant strain of \textit{S. pneumoniae}.

**Antibiotic-resistant \textit{E. coli}**

In a series of studies investigating fecal colonization of children with antibiotic-resistant \textit{E. coli} in seven child-care centers, 19 percent of 79 children in diapers were colonized with trimethoprim-resistant \textit{E. coli}. All of the strains were multiresistant (109). This rate was higher than that noted among adults, including those receiving trimethoprim, and suggested that diapered children in child-care centers may be a reservoir for this organism. A subsequent study compared diapered children in 12 child-care centers with diapered children not attending child care and with medical students (table 7) (11). The prevalence of fecal colonization with trimethoprim-resistant \textit{E. coli} among children in the child-care centers (31 percent) was higher than in the comparison group of children (6 percent) and medical students (8 percent) \((p<0.001\)). All trimethoprim-resistant \textit{E. coli} isolates from children and the majority of isolates from adults were resistant to other antimicrobial agents. Proportions of colonized children varied among the child-care centers and ranged from 0 to 59 percent. In a case-control study, children younger than 24 months of age attending child-care centers were at higher risk for colonization than older children \((OR=2.2, 95\, \text{percent CI 1.1-4.3})\), and children attending a center with more than 40 diapered children were at higher risk than those attending centers with fewer children in diapers \((OR=3.0, 95\, \text{percent CI 1.5-6.0})\) (11).

A study to determine the prevalence of trimethoprim-resistant \textit{E. coli} among household members of children attending child-care centers found colonization in 26 percent of family members of 23 children; 13 (57 percent) of the children were colonized (127). Significantly more members of households of colonized children were colonized than persons in households of children who were not colonized \((OR=13.3, 95\, \text{percent CI 1.3-176.6, } p<0.01\)). Colonization was more frequent among mothers (35 percent) and siblings (30 percent) than among fathers (12 percent). In these studies, 83 distinct strains were identified among 367 trimethoprim-resistant \textit{E. coli} isolates from 72 children, one of which was recovered from 61 percent of the children colonized in one child-care center (131).

The failure to find a significant association between colonization by trimethoprim-resistant \textit{E. coli} and antibiotic use among children in child care may reflect an inaccurate accounting of the use of antibiotics when the child-care facility is the source of information. Alternatively, a high overall use of antibiotics, crowding, and increased transmission among children in child-care settings together may obscure measurement.

\begin{table}
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Population} & \textbf{No. of subjects studied} & \textbf{\% trimethoprim-resistant \textit{E. coli}}} \\
\hline
Children in child-care centers & 203 & 31 \\
Children in well-child clinic & 56 & 6 \\
Medical students & 64 & 8 \\
80 & 8 & 8 \\
Clinical isolates in the United States & 430-2,716 & 4-6 \\
\hline
\end{tabular}
\caption{Prevalence of fecal colonization with trimethoprim-resistant \textit{Escherichia coli} among several populations\*}
\end{table}

\* References: Reves and Jones (108), Reves et al. (109, 110), Strangert (111), and Stahlberg (112).
of individual risk. Further research is needed to determine the association between antibiotic use and the prevalence of trimethoprim-resistant *E. coli* in populations of children enrolled and not enrolled in child care.

**BLOOD-BORNE PATHOGENS**

The risk of transmission of blood-borne pathogens in child-care settings is low. However, injuries, scratching, and biting occur commonly among toddlers and preschool-age children. The seriousness of infections acquired by contact with blood warrant careful consideration of the potential risks and use of preventive strategies in the child-care setting.

**Blood exposure in child-care settings**

A number of epidemiologic studies have assessed the incidence of injuries among children in child care, although specific information is lacking on the presence and amount of blood present (132-135). In one study, lacerations accounted for 44 percent of child-care center injuries which required medical attention (133). Bites were reported in 1.4 percent of injuries. Cuts and lacerations also were found to be the most frequent injuries (31 percent) requiring medical attention in a national survey of 1,797 child-care centers in which the overall injury rate was 1.5 per 100,000 child hours (135). Scraps and puncture wounds accounted for an additional 4 percent of injuries, and bites accounted for an additional 5 percent. Although neither of these studies described the bite injuries, reports were limited to those requiring medical attention and, thus, reported bites are likely to have been associated with bleeding. Up to 50 percent of children in child care have been estimated to sustain bites (136); most are minor and do not break the skin. Biting in child care is observed most frequently among toddlers compared with infants or with children over 2 years of age.

A prospective study investigating rates, severity, and etiology of injuries in child-care centers found that minor injuries accounted for 90 percent of all injuries reported (137). The majority of injuries were caused by behaviors of the injured child or other children rather than equipment or the building. Children who sustained multiple minor injuries were more likely to experience more severe injuries. This information could be used in designing and targeting injury prevention practices, especially those which are likely to result in bleeding.

**Hepatitis B virus**

There is evidence that hepatitis B virus transmission may occur in the child-care setting. A serologic survey conducted among 2,196 children attending 52 nursery schools in Japan over a 3-year period identified 10 children in five schools who were positive for hepatitis B surface antigen (HBsAg) (138). There were no HBsAg-positive family members among eight of the 10 children. The father of one of the remaining children was positive for HBsAg and negative for hepatitis B e antigen (HBeAg), a marker of infectivity. Two younger siblings of the other child were HBsAg-positive, but since the parents and older siblings were HBsAg-negative it was thought that the child became infected in nursery school and subsequently infected his younger siblings. At least one HBsAg carrier with HBeAg attended each of the five nursery schools in which transmission was thought to occur.

There are two published reports of transmission of hepatitis B virus in child-care settings in the United States (139, 140). In one episode, transmission occurred between two children. The infected child exhibited aggressive behavior and was known to bite other children (139). In another report, a child-care worker administered first aid to a hepatitis B virus-infected child who had fallen and sustained a bleeding laceration on his scalp (140). The child-care worker had chapped hands with open sores which were exposed directly to the child’s blood. Transmission did not occur in two other investigations following identification of a hepatitis B virus carrier in child care (139, 141).

**Human immunodeficiency virus**

The number of young children infected in utero with human immunodeficiency virus (HIV) is increasing (142). The HIV epidemic has spread to young women of childbearing age who are intravenous drug abusers themselves or have sexual partners who are drug abusers or are bisexual (143). In 1988, a seroprevalence survey among newborn infants estimated that 1.5 per 1,000 women giving birth were infected with HIV (144). Based on a perinatal transmission rate of 30 percent, an estimated 1,800 newborns per year are infected with HIV. Using a similar approach, investigators reported a prevalence rate of 2.1 HIV-infected women per 1,000 women giving birth in Massachusetts (145). Recent advances in treating HIV-infected pregnant women may reduce the rate of perinatal transmission (146), but may be offset by the increased number of women of childbearing age who become infected. Also, children with HIV infection are living longer because of earlier diagnosis, prevention of infections, and new advances in antiviral therapy (147). The combination of an increasing number of infants infected with HIV and extension of their survival time...
is likely to result in more HIV-infected children enrolled in child care.

Despite the concern that given certain circumstances there may be opportunities for transmission, there have not been any documented cases of HIV transmission in the child-care setting. In the general population, horizontal transmission from HIV-infected persons to uninfected contacts in the absence of any of the common modes of transmission is infrequent. In 17 studies there was no transmission of HIV from infected persons to 1,167 household contacts in whom the risk for sexual or needle transmission was ruled out (148). Further, there have been several reports in which transmission did not occur following a bite received from an HIV-infected person, some of which involved breaking the skin (149–151). In other cases where transmission of HIV to household members was not attributable to common routes of transmission, blood exposure was implicated (152–155). The specific risk for HIV transmission is not known when an uninfected person bites and is exposed to the blood of an HIV-infected individual, or when an uninfected person is bitten by an HIV-infected person who is bleeding and the victim’s open wound is exposed to infected blood.

The American Academy of Pediatrics advocates enrollment of children with HIV infection in child care based on several factors, including evaluation of their health status by their health-care provider or other qualified person, whether they will receive optimal care, and whether their health status poses a risk to others (2). Appropriate attitudes among parents of children in child care and among child-care providers concerning HIV-infected children and the transmission of HIV are essential to providing safe and caring child-care environments. Discriminatory attitudes and behaviors stem from fear based on erroneous information, such as the belief that HIV can be transmitted through common child-care contacts (e.g., urine, stool, tears, vomitus, sharing food or utensils, or kissing) (156). Understanding the potential risks and knowing that appropriate safety practices are in place should alleviate unwarranted fears of parents and providers and result in optimal child-care environments for all children.

FINANCIAL IMPACT

Child care is an important factor in the financial burden of infectious illnesses in young children because of its association with higher rates of infectious diseases, increased severity of some diseases, increased antibiotic use, and transmission of antibiotic-resistant pathogens. The cost to society of child-care-associated infectious illnesses is dependent, in part, on the proportion of children attending child-care facilities, which may vary according to geographic region. Nevertheless, the 10 percent population risk attributable to child-care exposure estimated from the household survey conducted in Atlanta was used to estimate the economic impact of upper respiratory tract infections in young children nationwide. Using 1988 average costs ($55), physician visits for upper respiratory tract illnesses attributable to child care were estimated to cost $90 million (157).

In a study conducted to determine the costs associated with diarrhea in an ambulatory population of children <36 months of age, the mean cost per episode of diarrhea seen in an outpatient practice was $289, including office visits, laboratory tests, medications, dietary changes and oral rehydration solutions, travel, missed work, extra diapers, and extra child care (106). The costs of missed work (household income divided by number of working days per year) and extra child care accounted for nearly 52 percent of the total cost.

Another study evaluated socioeconomic characteristics of families and care strategies used by parents of children in child care when children with diarrhea were too ill to attend (158). Direct medical costs were estimated based on the number of episodes of diarrhea observed during 2 years of monitoring and the probability that any given episode would be seen by a physician. The average total direct and indirect cost of diarrheal illness was $172 per child-year; 74 percent of this cost was attributable to nonmedical indirect costs associated with the child’s absence from child care.

Time lost by parents from work to care for ill children accounts for a large portion of the costs associated with childhood diseases. For example, prevention of varicella in children was estimated to save more than $325 million per year in associated parental work loss (159).

PREVENTION AND CONTROL OF INFECTIOUS DISEASES IN CHILD CARE

National health and safety guidelines for child-care programs

A collaborative project was launched by the American Public Health Association and the American Academy of Pediatrics, supported by the Maternal and Child Health Bureau, Department of Health and Human Services, to develop national health and safety performance standards for out-of-home child-care programs. The results of this project were published in 1992 as guidelines for out-of-home child-care programs (2). The standards set forth goals for quality child care and guidelines for implementation. Recom-
mendations regarding control of infectious diseases in child-care centers include specific standards and procedures concerning personal hygiene (handwashing), disinfection, exclusion policies, management of ill children, immunization requirements, blood exposure, and reporting of outbreaks to a health agency. Compliance with the standards is variable, depending on factors such as the cost of implementation and state and local laws. A survey of child-care centers throughout the United States showed that compliance with the standards and procedures for diarrhea ranged from 20 percent (percent of centers that complied with reporting diarrhea outbreaks) to 99 percent (percent of centers that used single-use disposable towels for drying hands) (160). Compliance varied by state and was not associated with center characteristics.

**Disease-specific prevention and control**

*Respiratory tract illnesses.* Although whenever possible young children should not be exposed to persons known to be contagious, most often this is not practical since persons with respiratory tract infections may be contagious for several days before symptoms appear or may be infected but remain asymptomatic. Children who are afebrile and have mild or moderate respiratory tract symptoms should not be excluded from child care unless their illness limits their activities or the child-care staff are unable to provide special care needed by the sick child. Respiratory illnesses requiring exclusion of children from child care are those with an identified specified cause (e.g., group A β-hemolytic streptococcus pharyngitis) and are listed in the American Public Health Association/American Academy of Pediatrics guidelines (2), and in the American Academy of Pediatrics *Red Book* (161). Similar recommendations apply to child-care staff. Good personal hygiene and appropriate handling of secretions help control the spread of organisms transmitted through the respiratory route. A study of child-care facilities where invasive *H. influenzae* type b disease occurred found that child-care personnel reused towels or handkerchiefs to wipe children’s noses more often than personnel at facilities in which *H. influenzae* type b disease was absent (162).

Exclusive breast-feeding has been found to protect infants from otitis media. Infants who were breast-fed exclusively for 4 or more months were at decreased risk for acute otitis media compared with infants not breast-fed, partially breast-fed, or breast-fed for less than 4 months (OR = 0.72, 95 percent CI 0.54–0.95); the risk for having three or more episodes of otitis media was decreased further (OR = 0.54, 95 percent CI 0.35–0.81) (163). Thus, continuing to breast-feed the young infant who attends child care is important. Several highly effective *H. influenzae* type b conjugate vaccines are available and recommended for routine use in children beginning at age 2 months (161). Currently available unconjugated pneumococcal and meningococcal vaccines are not effective in children younger than 2 years of age because children have an impaired response to unconjugated polysaccharide antigens at this age (164). Conjugated pneumococcal and meningococcal vaccines are being developed for use in young children.

Since most cases of acute otitis media are preceded by viral infections, viral vaccines that are effective in young children may be expected to reduce the incidence of otitis media. The results of two studies indicate that prevention of influenza viral infections can decrease the incidence of otitis media in children attending child care. Children aged 1–3 years attending child care in Finland were given a trivalent subvirion influenzae vaccine prior to an influenzae A epidemic in 1988–1989 (165). There was a 36 percent reduction in the number of vaccinees who developed acute otitis media compared with the control group of unvaccinated children of the same age and background. Similar results were obtained in a prospective cohort study in the United States among children 6–30 months of age attending eight child-care centers. Acute otitis media was reduced by 32 percent and serious otitis media by 28 percent among children vaccinated with a trivalent subvirion influenzae vaccine compared with an unvaccinated control group (166).

A vaccine against respiratory syncytial virus, a leading cause of respiratory tract infections in young children, is under development. Availability of an effective respiratory syncytial virus vaccine for young children would be an important advance in the prevention of viral respiratory tract illness in child-care attendees and also serve to reduce the incidence of otitis media which may follow such illnesses.

*Enteric disease.* No single measure has proved to be adequate in reducing risk of diarrheal disease in child-care centers. Effective prevention strategies include proper handwashing, diapering, disinfection procedures, and policies essential to limiting spread of diarrhea-causing organisms, such as exclusion of ill children and having food preparation done by personnel other than child-care staff who work with diapered children. The use of automated, faucet-free handwashing sinks also would help to decrease fecal contamination. Community-wide education on hygienic practices has been shown to be effective in controlling community outbreaks of shigellosis associated with child-care centers (167). Breast-feeding of infants has been associated with a decreased risk for diarrhea (168). Newly developed rotavirus vaccines have been...
shown to be 50–80 percent efficacious in infants in multicenter trials (169–171). A recent cost-effectiveness analysis concluded that routine immunization of children under 1 year of age with a partially effective rotavirus vaccine against severe diarrhea would be cost-effective (172).

Hepatitis A. Good personal hygiene and the use of appropriate disinfection procedures are important prevention measures against hepatitis A virus infection. Two inactivated hepatitis A virus vaccines for persons 2 years of age and older were licensed in the United States in 1995 and 1996. Although recommendations by the Advisory Committee on Immunization Practices do not specifically target children in child care, their household contacts, or child-care providers, immunization is recommended for persons at risk of infection.

Varicella. Exclusion of children with varicella from child care until all lesions are crusted has been recommended to prevent transmission of the virus (2). The effectiveness of this policy is questionable, because varicella virus is airborne and infected children are contagious 2 days before the onset of rash, when there may be no other apparent symptoms. Many parents have welcomed an exposure to varicella for young children at times they considered convenient for the child to be infected. After more than a decade of development and testing, a live attenuated varicella vaccine was licensed in March 1995. It is recommended for routine immunization of children at 12–18 months of age (American Academy of Pediatrics (173)).

Cytomegalovirus. The practice of handwashing following contact with the urine or saliva of young children is essential in preventing spread of cytomegalovirus. Also, contact with saliva of young children who are likely to be shedding cytomegalovirus should be avoided, e.g., kissing a child on the mouth or sharing food or eating or drinking utensils. Efforts to develop vaccines to prevent cytomegalovirus disease have spanned more than 20 years and are ongoing. A new recombinant cytomegalovirus vaccine is being tested in multicenter trials in adults and in toddlers.

Blood-borne pathogens. Strict adherence to safety procedures for contact with blood, including the use of gloves and proper disinfection techniques, is essential in preventing the transmission of blood-borne pathogens. The specific procedures, or universal precautions, established by the American Public Health Association and the American Academy of Pediatrics (2) should be incorporated into the routine training and supervision of all child-care staff. Immunization against hepatitis B is now part of the recommended immunization schedule for infants and children. Immunization with hepatitis B vaccine should be required for children to attend child care, and immunization of child-care workers should be considered. However, since many young children and child-care workers have not been immunized, it should be assumed that there is a risk of hepatitis B transmission in child-care settings.

Routine immunization of children less than 2 years of age

The combined recommended childhood immunization schedule of the Advisory Committee on Immunization Practices and the American Academy of Pediatrics includes immunization against 10 diseases, including diphtheria, tetanus, pertussis, measles, mumps, rubella, poliomyelitis, H. influenzae type b, hepatitis B virus, and varicella (174). The association between diphtheria, tetanus, pertussis, measles, mumps, and rubella and child-care attendance has not been established because vaccines against these diseases were used widely before the rise in use of group child care. There have been, and continues to be, frequent changes in immunization recommendations in response to the development of new vaccines and the changing epidemiology of vaccine preventable diseases. Since 1990, when H. influenzae type b vaccine was recommended for use in infants, the incidence of H. influenzae type b disease in young children has declined dramatically (121). There has not been sufficient time since licensure of the varicella vaccine to observe its impact in the child-care setting.

Most states have laws requiring that children attending licensed child-care programs be fully immunized, and, thus, it is not surprising that children in licensed child care have been shown to have higher immunization levels than children of the same age who do not attend child care (175). Special efforts may be needed to assure that children in unlicensed child-care facilities are fully immunized.

SUMMARY

The increasing number of mothers of young children in the work force and the resultant escalated use of child-care facilities has had a marked effect on the epidemiology of infectious diseases in young children. Children attending child care are at high risk for respiratory and gastrointestinal tract illnesses. The high prevalence of infectious diseases in the child-care setting is accompanied by high usage of antibiotics, which in turn has resulted in spread of antibiotic-resistant organisms. The infectious disease standards of the American Public Health Association/American Academy of Pediatrics guidelines were developed to

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prevent and limit transmission of infectious diseases in the child-care setting. Adherence to these standards is essential but will not completely eliminate the increased risk of infectious diseases in child-care settings.

New challenges need to be addressed to assure that optimal health promotion and disease prevention is practiced in child-care settings. We approach the 21st century with a vast amount of medical knowledge, molecular technology, highly effective vaccines, and powerful antimicrobial agents. However, at the same time we face many unsolved serious problems, such as preventing or controlling the emergence and spread of antibiotic-resistant organisms that adversely affect our ability to treat infectious diseases. Further research is needed concerning the relations between child care, the use of antibiotics, and transmission of antibiotic-resistant organisms in order to design and implement the most effective strategies for preventing or controlling antibiotic resistance. The potential risk for transmission of HIV in the child-care setting also needs to be recognized, and procedures to prevent transmission of blood-borne pathogens need to be followed.

Monitoring compliance with national standards for child-care facilities, dissemination of information concerning infectious diseases and use of antibiotics, and development and use of new vaccines are strategies which should be used to help protect the health of children in child-care environments.

REFERENCES


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