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# 3 Infections Associated with Group Childcare

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In 2007, 325,289 licensed childcare facilities in the United States provided care for 9.5 million children, employing 1.2 million providers (http://www.naccrra.org). Aggregation of young children potentiates transmission of organisms that can produce disease in other children, adult care providers, parents, and community contacts. Group childcare settings can increase the frequency of certain diseases and amplify outbreaks of illness (Table 3-1). An increase in antibiotic use to facilitate earlier return to care enhances the potential for emergence of resistant organisms, resulting in an increased economic burden to individuals and society.[1–3] Children newly entered into group childcare are at especially high risk of enteric and respiratory tract infections.[4–9] As a consequence of these infections, attendees may be protected against respiratory tract viral infections and reactive airway diseases during subsequent years.[10] An 8-year prospective cohort study conducted from 1998 to 2006 in Quebec comparing children enrolled in home care with those in small or large group childcare observed an increase in infections at initiation of large group care. Enrollment in group childcare before 2.5 years of age resulted in decreased maternal reporting of respiratory and gastrointestinal tract infections and otitis media during elementary school years.[11] Frequent infections early in life, resulting from sibling and group childcare exposure, may be protective against atopic disease in later childhood.[12] A prospective evaluation of a birth cohort of almost 4000 children in the Netherlands demonstrated that children who were enrolled in group childcare between birth and 2 years of age had more parental reported episodes of airway symptoms in the first 4 years of life but fewer reported symptoms from 4 to 8 years of age. A longitudinal repeated-event analysis did not reveal protection from early childcare enrollment with respect to asthma symptoms, hyperresponsiveness, or allergic sensitization at the age of 8 years.[13]

## CHILDCARE ARRANGEMENTS

Quantifying the types of childcare arrangements and the number of children participating in each is challenging because of different ascertainment methods used in several data sources. The U.S. Census Bureau conducts the Survey of Income and Program participation (SIPP), which collects information about childcare arrangements for children <15 years of age. A primary care arrangement is defined as the arrangement used the most hours per week. In 2006, 47% of children <15 years of age were cared for by a relative; 24% attended an organized care facility including group childcare, nursery or preschool or Head Start; 16% were in non-relative provided care, the majority of which was outside the child's primary residence; 11% were in an unspecified arrangement; and 2% were not enrolled in a regular arrangement[14] (www.census.gov/population/www/socdemo/2006_detailedtables.html). Types of facilities can be classified by size of enrollment, age of enrollees, and environmental characteristics of the facility. Grouping of children by age varies by setting but in organized care facilities children usually are separated into: infants (6 weeks through 12 months), toddlers (13 through 35 months), preschool (36 months through 59 months), and school-aged children (5 through 12 years), which has relevance to infectious disease epidemiology with regard to regulation and monitoring. Most non-relative care provided in an organized care facility is subject to state licensing and regulation, whereas care by a relative in a child's or provider's home may not be subject to state regulations and monitoring.

## EPIDEMIOLOGY AND ETIOLOGY OF INFECTIONS

Although most infectious diseases have the propensity to propagate in childcare settings, diseases shown in Table 3-1 commonly are associated with outbreaks.

### Enteric Infections

Outbreaks of diarrhea occur at a rate of approximately 3 per year per childcare center and are associated most frequently with organisms that cause infection after ingestion of a low inoculum. These organisms generally are transmitted from person to person[15,16] and include: rotavirus, sapovirus, norovirus, astrovirus, enteric adenovirus, *Giardia intestinalis, Cryptosporidium, Shigella, Escherichia coli* O157:H7 and other Shiga-toxin producing *E. coli* (STEC), *E. coli* O114, enteropathogenic *E. coli*, and *Clostridium difficile.*[15,17–29] These fecal coliforms[30,31] and enteric viruses contaminate the environment;[32] contamination rates are highest during outbreaks of diarrhea. Attack rates and frequency of asymptomatic excretion of these organisms in children attending group childcare are shown

**TABLE 3-1. Association of Infectious Diseases with Group Childcare Settings**

| Disease or Infection | Risk Factors and Association with Outbreaks |
|---|---|
| **Enteric** | Close person-to-person contact, fecal-oral contact, suboptimal hand hygiene, and food preparation practices |
| Viral | |
| Rotaviruses, enteric adenoviruses, astroviruses, noroviruses, hepatitis A virus (HAV) | Commonly associated with outbreaks<br>HAV and rotavirus are vaccine preventable |
| Bacterial | |
| *Shigella, Escherichia coli* O157:H7 | Commonly associated with outbreaks |
| *Campylobacter* spp., *Salmonella* spp., *Clostridium difficile* | Less commonly associated with outbreaks |
| Parasitic | |
| *Giardia intestinalis*<br>*Cryptosporidium parvum* | Commonly associated with outbreaks |
| **Respiratory tract** (acute upper and lower respiratory tract infections and invasive disease) | Aerosolization and respiratory droplets, person-to-person contact, suboptimal hand hygiene |
| Bacterial | |
| *Haemophilus influenzae* type b (Hib) | Few outbreaks; Hib is vaccine preventable |
| *Streptococcus pneumoniae* | Few outbreaks; vaccine preventable invasive *S. pneumoniae* caused by serotypes not in vaccine |
| Group A streptococcus | Few outbreaks and low risk of secondary cases |
| *Neisseria meningitidis* | Few outbreaks; some serogroups vaccine preventable; *N. meningitidis* caused by serogroups not in vaccine in people ≥2 years of age |
| *Bordetella pertussis* | Increasingly associated with outbreaks in childcare centers and schools; vaccine preventable |
| Mycobacterium tuberculosis | Occasional outbreaks, usually as a result of contact with an infectious adult care provider |
| *Kingella kingae* | Outbreaks rare; oropharynx usual habitat; usually manifest as arthritis and osteomyelitis |
| Viral | |
| Rhinoviruses, parainfluenza, influenza, respiratory vaccinesyncytial virus (RSV), respiratory adenoviruses, influenza, metapneumoviruses, bocavirus | Disease usually caused by same organisms circulating in the community; influenza is vaccine preventable in children ≥6 months of age |
| **Multiple organ systems** | |
| Cytomegalovirus | Prevalent asymptomatic excretion with transmission from children to providers |
| Parvovirus B19 | Outbreaks reported; risk to susceptible pregnant women and immunocompromised |
| Varicella-zoster virus (VZV) | Outbreaks in childcare centers occur. VZV is vaccine preventable in children ≥12 months of age. Zoster lesions present low risk of infection |
| Herpes simplex virus (HSV) | Low risk of transmission from active lesions and oral secretions |
| Hepatitis B virus | Rarely occurs in childcare centers; vaccine preventable |
| Hepatitis C virus | No documented cases of transmission in the childcare setting |
| Human immunodeficiency virus (HIV) | No documented cases of transmission in the childcare setting |
| **Skin** | Close person-to-person contact |
| Staphylococcal and streptococcal impetigo | Transmission increased by close person-to-person contact with lesions; outbreaks less likely with decreased incidence of varicella infections; methicillin-resistant *Staphylococcus aureus* (MRSA) infection common |
| Scabies | Outbreaks in group childcare reported |
| Pediculosis | Common in children attending group childcare |
| Ringworm | *Tinea corporis* and *T. capitis* outbreaks associated with childcare |
| **Conjunctiva** | Outbreaks in group childcare reported with both bacterial and viral etiologies |

in Table 3-2. Reported attack rates depend on several factors, including methods used for organism detection.[23,24]

Enteric viruses are the predominant etiology of diarrheal syndromes among children in group care.[33] Environmental swabs corroborated stool virus detection in 45% of outbreaks.[34] With the marked decline in rotavirus disease due to the success of the rotavirus immunization program, norovirus may be the most common viral enteric pathogen in childcare centers.

Organisms generally associated with foodborne outbreaks, including *Salmonella* and *Campylobacter jejuni,* infrequently are associated with diarrhea in the childcare setting. Report of an outbreak of diarrhea in 14 of 67 (21%) exposed children and adult care providers associated with ingestion of fried rice contaminated with *Bacillus cereus,*[35] however, highlights the fact that foodborne outbreaks can occur in the childcare setting, especially when food is prepared and served at the center.

Bacterial pathogens that have the potential to cause severe systemic infections, including *E. coli* O157:H7 and other STEC,[28] have been associated with fecal–oral transmission in group childcare settings. An outbreak of *E. coli* O157:H7 occurred in a childcare center in Alberta, Canada in 2002 likely after introduction by a 3-year-old enrollee who developed hemolytic–uremic syndrome following farm animal contact. The diarrheal attack rate was 23% among enrollees, which is comparable with attack rates reported during previous childcare-associated outbreaks of *E. coli* O157:H7. Prolonged asymptomatic shedding and subclinical cases in concert with poor hygiene and toileting practices likely contributed to propagation of the outbreak.[36]

*Shigella sonnei* causes periodic multicommunity outbreaks in group childcare. Childcare attendance and age <60 months were associated with illness in a dispersed community outbreak of molecularly related strains of *S. sonnei* among traditionally observant Jewish children in New York City in 2000.[37] Multiple illnesses in a single household were determined to be due to intrahousehold secondary transmission. A multicommunity outbreak of over 1600 culture-confirmed cases in the greater metropolitan area of Cincinnati, Ohio from May to September, 2001 had an overall mean attack rate of 10% among childcare center enrollees. Highest attack rates occurred among newly or incompletely toilet-trained enrollees and lowest attack rates among diapered children. The attack rate was 6% among staff. Secondary transmission was facilitated by poor hygiene practices, including inaccessible

**TABLE 3-2. Outbreaks of Diarrhea by Organism**

| Organism | Attack Rate (Enrollees) (%) | Secondary Attack Rate (Family Members) (%) | Asymptomatic Excretion (Enrollees) |
|---|---|---|---|
| Rotavirus | 50 | 15–80 | Common |
| Enteric adenovirus | 40 | Unknown | Common |
| Astrovirus | 50–90 | Unknown | Common |
| Calicivirus | 50 | Unknown | Common |
| *Giardia intestinalis* | 17–54 | 15–50 | Common |
| *Cryptosporidium* | 33–74 | 25–60 | Common |
| *Shigella* | 33–73 | 25–50 | Uncommon |
| *Escherichia coli* | | | |
| O157:H7 | 29, 34 | Unknown | Uncommon |
| O114:NM | 67 | Unknown | Uncommon |
| O111:K58 | 56, 94 | Unknown | Uncommon |
| *Clostridium difficile* | 32 | Unknown | Common |

handwashing supplies and incomplete diaper disposal practices, as well as recreational activities involving water.[38] A prolonged multistate increase of shigellosis due to organisms with similar biochemical and genetic profiles occurred in the south and mid-Atlantic areas from June 2001 to March 2003. A substantial proportion of cases were associated with group childcare.[39] From May to October of 2005, 639 cases of multidrug-resistant *S. sonnei* were reported in northwest Missouri. A case-control investigation of 39 licensed childcare centers demonstrated that centers with ≥1 sink or a diapering station in each room were less likely to have cases, showing the essential importance of these practices to reduce the propagation of shigellosis in childcare centers.[40] Investigators in North Carolina demonstrated that proper diapering and hand hygiene practices, and food-preparation equipment decreased the incidence of diarrheal illness among children and staff in out-of-home childcare centers.[41]

Spread of diarrhea pathogens from index cases in the childcare setting into families has been reported for many enteropathogens (see Table 3-2), with secondary attack rates ranging from 15% to 80%. A retrospective evaluation of transmission of infectious gastroenteritis (80% due to rotavirus) in 936 households in northern California revealed a secondary household attack rate of 9%. Older children in the households had a 2- to 8-fold greater risk of secondary infection than adults.[42] During outbreaks of diarrhea in childcare centers, asymptomatic excretion of enteropathogens is frequent[15,23,24,43–46] (see Table 3-2). During outbreaks associated with enteric viruses and *G. intestinalis* in children <3 years of age, asymptomatic infection occurs in up to 50% of infected children. In one longitudinal study of diarrhea in 82 children <2 years of age in a childcare center, more than 2700 stool specimens were collected on a weekly basis.[45] Using enzyme immunoassays, 21 of 27 (78%) children infected with *G. intestinalis* were asymptomatic and 19 of 37 (51%) children with rotavirus were asymptomatic. A point-prevalence evaluation of 230 asymptomatic preschool children attending childcare in southwest Wales and inner London demonstrated a 1.3% fecal colonization rate with both *Cryptosporidium* and *Giardia* spp.[47] The role that asymptomatic excretion of enteropathogens plays in spread of disease is unknown.

Acute infectious diarrhea is two to three times more common in children in childcare than in age-matched children cared for in their homes.[4,48,49] Approximately 20% of clinic visits for acute diarrheal illness among children younger than 3 years of age are attributable to childcare attendance [4]. In addition, the incidence of diarrheal illness is 3-fold higher among children in their first month in out-of-home childcare than in children cared for at home.[4,5]

Diarrhea occurs 17 times more frequently in diapered children than in children not wearing diapers.[50] Children who are diapered are more likely to be younger than children who are not; therefore, higher attack rates merely may represent exposure of a younger, nonimmune cohort. In a multicommunity group childcare outbreak of *S. sonnei*, the highest attack rates were noted in rooms where both toilet-trained and diapered children were co-mingled (14%) compared with rooms with toilet-trained children only (9%) and rooms with diapered children only (5%), despite comparable availability of sinks and toilets.[38]

## Rotavirus

Rotaviruses are the most common etiology of significant symptomatic diarrhea in children <2 years of age, although rates of diarrhea have decreased since implementation of rotavirus immunization.[51] Infections are transmitted primarily from person to person by the fecal-oral route. Rotavirus can be isolated from human stools for approximately 21 days after illness onset and rotavirus RNA has been detected on toys and surfaces in childcare centers.[32] The highest attack rates for rotavirus infections have occurred in infants and children enrolled in group childcare.

Primary prevention of rotavirus in all settings has been accomplished with administration of one of two licensed rotavirus vaccines. Before introduction of rotavirus vaccines in the U.S. in 2006, rotavirus caused an estimated 20 to 60 deaths, 55,000 to 70,000 hospitalizations, 205,000 to 272,000 emergency department visits, and 400,000 outpatient visits annually among children less than 5 years of age. The 2007–08 and 2008–09 rotavirus seasons were notable for their decreased duration, later onset, and fewer positive tests, compared with median data for 2000–2006 from a national network of sentinel laboratories.[52,53]

## Hepatitis A Virus

Hepatitis A virus (HAV) infections usually are mild or asymptomatic in children. Less than 5% of children <3 years of age and <10% of children between 4 and 6 years of age with HAV infection develop jaundice. The first outbreak of HAV in a childcare center was reported in 1973 in North Carolina;[54] outbreaks subsequently were recognized throughout the U.S.[55] Peak viral titers in stool and greatest infectivity occur during the 2 weeks before onset of symptoms. Outbreaks in childcare centers generally are not recognized until illness becomes apparent in older children or adults.[55] Prior to routine use of hepatitis A vaccine in children in the U.S., approximately 15% of episodes of HAV infection were estimated to be associated with childcare centers. HAV infections are transmitted in the childcare setting by the fecal-oral route and occur more frequently in settings that include diapered children. Large size and long hours of operation also are risk factors for outbreaks of HAV infection.[56]

The mainstays for prevention of HAV infection include maintenance of personal hygiene, hand hygiene, and disinfecting procedures. Universal administration of hepatitis A vaccine to toddlers in Israel in 1999 resulted in a notable absence of outbreaks of HAV in childcare and elementary school settings from 2000 through 2006.[57] Universal administration of 2 doses of hepatitis A vaccine to all children, beginning at 1 year (12 through 23 months) of age, with the 2 doses administered at least 6 months apart is recommended in the U.S.[58] Administration of hepatitis A vaccine or immune globulin to unimmunized, immunocompetent people 12 months through 40 years of age for postexposure prophylaxis also is recommended.[59,60] A case-control study to evaluate the effectiveness of an HAV vaccination program targeted at childcare attendees between 2 and 5 years of age found that people with direct contact with a childcare center were protected against disease. Furthermore, the 6-fold greater risk of HAV infection that occurred in people who had contact with a childcare center prior to implementation of the hepatitis A immunization program in Maricopa County, Arizona was not found in the post-vaccination case-control study.[61] Enhanced population-based surveillance conducted by health departments among six U.S. sites from 2005 to 2007 was notable for 1156 cases among 29.8 million people. Being an employee or child in a childcare center accounted

for 8% of cases, while international travel and contact with a case were more frequent risk factors associated with 46% and 15% of hepatitis A cases. Despite the decline in the incidence of HAV, continued education, training, and monitoring of staff regarding appropriate hygienic practices are essential components of any preventive plan.

## Respiratory Tract Infections

Children <2 years of age attending childcare centers have an increased number of upper and lower respiratory tract illnesses compared with age-matched children cared for at home.[4,6,62,63] Approximately 10% to 17% of respiratory tract illnesses in U.S. children <5 years of age are attributable to childcare attendance.[64,65] A prospective cohort study found that 89% of disease episodes among children attending a childcare center are respiratory tract infections (RTIs).[66] Another prospective cohort study following 119 children through 24 months of age from 2006 to 2008 demonstrated a mean annual incidence of RTI of 4.2 per child during the first year and 1.2 during the second year of the study. One or more viruses were detected by real-time reverse transcriptase polymerase chain reaction (rRT-PCR) from two-thirds of the episodes.[67] Infections with human metapneumovirus (HMPV) and human bocavirus (HBoV) also have been reported in childcare enrollees.[67–69]

In a retrospective cohort study of 2568 children from 1 to 7 years of age, 1-year-old children cared for in childcare centers, when compared to those cared for at home, had an increased risk of the common cold (relative risk (RR), 1.7; 95% CI, 1.4 to 2.0), otitis media (RR, 2.0; 95% CI, 1.6 to 2.5), and pneumonia (RR, 9.7; 95% CI, 2.3 to 40.6).[62] In a prospective cohort study in France, the risk of upper respiratory tract illnesses (URTIs) was higher for those cared for in small centers (odds ratio (OR), 2.2; 95% CI, 1.4–3.4) and large centers (OR, 1.2; 95% CI, 0.8–1.8) compared with those in family childcare homes. The intermediate risk for those in large childcare centers may have resulted from segregation in those centers into small classrooms. A national registry-based study of Danish children from birth to 5 years of age revealed that for children under 1 year of age, the first 6 months of enrollment in group childcare were associated with a 69% higher incidence of hospitalizations for acute respiratory tract infections compared with children in home care. The incidence of hospitalization decreased after 6 months of group childcare enrollment and was comparable with children in home care after >12 months of enrollment.[70]

Respiratory tract infections that have been studied in the childcare setting include pharyngitis, sinusitis, otitis media, common cold, bronchiolitis, and pneumonia.[6,62,63,65,71] Organisms responsible for illness in children in childcare settings are similar to organisms that circulate in the community and include respiratory syncytial virus, parainfluenza viruses, adenovirus, rhinovirus, coronavirus, influenza viruses, parvovirus B19, and *Streptococcus pneumoniae.* Infections due to *Bordetella pertussis* in the U.S. have increased, with 8296 cases of pertussis reported in 2002 and 25,827 cases reported in 2004.[72–74] In 2010 over 6000 cases of pertussis were reported in California including 10 deaths in infants <3 months of age.[75] Incompletely immunized infants under 12 months of age often experience severe clinical disease. In many group childcare arrangements, adolescents and adults experiencing mild to moderate illnesses may be the source cases of pertussis. An outbreak of pertussis, occurring in a childcare center in northern Israel with 88% immunization coverage, resulted in infection among all of the unvaccinated children and only 7% of the vaccinated children.[76] In 2005, the American Academy of Pediatrics (AAP) and Advisory Committee on Immunization Practices (ACIP) recommended universal use of one of the licensed Tdap vaccines for those aged 10 through 64 years.[73,74] Childcare providers of any age with routine contact with infants <12 months of age also should receive a single dose of Tdap.[77]

An adult or adolescent also can be the index case for *Mycobacterium tuberculosis* infections in a group childcare setting; child-to-child transmission occurs infrequently.[78,79] An outbreak of tuberculosis (TB) associated with a private-home childcare facility in San Francisco, California occurred between 2002 and 2004.[80] Of 11 outbreak cases, 9 (82%) occurred in children <7 years of age; all had extensive contact with the private-home childcare facility, where the adult index patient spent considerable time. Isolates from 4 of the pediatric patients and 2 of the adult patients had identical molecular patterns. Thirty-six additional children and adult contacts had latent TB infections.[80] In a Swedish outbreak of TB following prolonged contact with a provider with cavitary disease in a childcare center, 17 children had radiographic evidence of pulmonary disease; 1 child had miliary disease and 17 had latent tuberculosis infection. The tuberculin skin test was effective in identifying infected children.[81] These outbreaks demonstrate that detection and contact investigation are paramount in reducing tuberculosis infection. High transmissibility of TB among residents of adult daycare centers also has been demonstrated.[82]

Person-to-person transmission of *Chlamydophila pneumoniae* among children in the childcare setting has been reported without occurrence of disease.[83] *Kingella kingae* colonizes the oropharynx and respiratory tracts of young children and has been associated with invasive disease.[84] The first reported outbreak of invasive *K. kingae* osteomyelitis/pyogenic arthritis occurred in a childcare center in 2003; 15 (13%) children older than 16 months of age were found to be colonized, with 9 children (45%) in the same class as the 2 children with invasive disease. Matching pulse field gel electrophoresis (PFGE) patterns supported child-to-child transmission.[85] Successive cases of *K. kingae* endocarditis and osteomyelitis occurred in two children attending a North Carolina childcare center in 2007 with a child enrollment of 14 children and 5 staff. Interaction with children from a co-owned childcare facility with 19 children >21 months of age and 5 staff resulted in an epidemiologic investigation of the attendees at both. A high rate of invasive disease, but a low rate of colonization (4%) was noted.[86]

Outbreaks of group A streptococcal (GAS) infection among children and adult staff in the childcare setting have been reported.[87–89] In a study of prevalence of GAS conducted in a childcare center after a fatal case of invasive disease, 25% of 258 children and 8% of 25 providers had GAS isolated from throat cultures.[87] Risk of carriage was increased in children who shared the room of the index case (OR, 2.7; 95% CI, 0.8 to 9.4). Perianal GAS infection and infection associated with varicella also have been reported.[88,90] A clone of GAS (emm type 4) was responsible for a community outbreak of streptococcal toxic shock syndrome among children attending a childcare center in northern Spain. The outbreak-associated strains were not isolated from pharyngotonsillar swabs of staff, childcare or household contacts of the colonized and infected children.[91]

The risk of acute otitis media (AOM) is increased in children in childcare, especially in children <2 years of age.[65,66,92,93] In one study, the incidence rate ratio for AOM was 1.5 in children in childcare compared with that in children in home care.[65] AOM is responsible for most antibiotic use in children <3 years of age in the childcare setting. Childcare attendance also has been associated with risk of developing recurrent AOM (>6 episodes in 1 year), as well as chronic otitis media with effusion persisting for more than 6 months.[94] The size of the childcare center was an important variable in the occurrence of frequent AOM in children younger than 12 months of age, varying from 16% in small care groups to 36% in large care groups.[93] Genotypically similar strains of nontypable *Haemophilus influenzae* and pneumococci were isolated from nasopharyngeal cultures from children attending childcare centers.[95,96]

Handwashing decreases the frequency of acute respiratory tract diseases in childcare.[97,98] A cluster, randomized, controlled trial of an infection control intervention including training of childcare staff regarding handwashing, transmission modes of infection, and aseptic techniques related to nose-wiping demonstrated a significant reduction in URTI among enrollees <24 months of age over 311 child-years of surveillance.[97] Because most infectious agents are communicable for a few days before and after clinical illness, exclusion from childcare of children with symptoms of upper respiratory tract infections probably will not decrease spread.

### Influenza

Rates of virus infection are highest among children <2 years of age and elderly people, and rates of complications are greatest among children of all ages with predisposing or underlying medical conditions. Among preschool-aged children with influenza infections, hospitalization rates range from 100 to 500/100,000 children, with highest hospitalization rates among children from birth to 1 year of age.[99] Influenza viruses are spread from person to person primarily through large respiratory tract droplets, either directly or by secondary contact with objects that are contaminated with infectious droplets. Children shed virus for several days prior to onset of clinical symptoms and are contagious for >10 days following symptom onset. Transmission of infections may be increased by close contact among children who are not able to contain their secretions.

Annual vaccination against influenza is the primary method for preventing influenza infection. Influenza vaccine is recommended annually for all people 6 months of age and older.[99] A single-blind randomized controlled trial conducted during the 1996 to 1997 influenza season in 10 childcare centers in San Diego, California revealed that vaccinating children against influenza reduced influenza-related illness among their household contacts.[100–102] In addition to preventing respiratory tract illness, several studies have shown the effectiveness of influenza vaccine in preventing AOM among children in childcare.[97,98,103] In one study of children 6 to 30 months of age in childcare centers, OR for AOM was 0.69 and the 95% CI was 0.49 to 0.98 for children who received influenza immunization.[104]

Routine use of intranasal influenza vaccine among healthy children may be cost effective and can be maximized by using group-based vaccination approaches. A prospective 2-year efficacy trial of intranasal influenza vaccine in healthy children 15 through 71 months of age demonstrated clinical as well as economic efficacy associated with focusing vaccination efforts on children in group settings.[105] Vaccinating children has been associated with protection of older people as well.[105–107]

Children with signs and symptoms of URTI should be cohorted. Ill childcare providers should be discouraged from providing care or having contact with children in group childcare. Vaccination of both child attendees and adult providers annually is recommended and both children and providers should receive frequent reminders regarding hand hygiene and respiratory etiquette to reduce influenza infections in group childcare settings. Frequently touched surfaces, toys, and commonly shared items should be cleaned at least daily and when visibly soiled as these items can serve as fomites in the transmission of viruses.[108]

The issue of childcare center closure as a strategy to prevent community spread of influenza was raised by the 2009 novel H1N1 influenza pandemic. A survey of 58% of families of 402 students in Perth, Australia who were affected by pandemic-related school closures revealed a substantial disruption of daily schedules. Almost half of the parents had work absences and 35% made alternative childcare arrangements. Children impacted by the school closures were more likely to report out-of-home activities during the closure period. Less than half (47%) of the parent respondents felt that the school closures were an effective response.[109] Childcare center and elementary school absences were two components of a surveillance system used for monitoring influenza activity in a U.S.–Mexico border community during the 2009 novel H1N1 influenza pandemic.[110]

## Invasive Bacterial Infection

Studies conducted before routine use of *Haemophilus influenzae* type b (Hib) vaccine in the U.S. showed that the risk of developing primary invasive Hib infection was higher among children attending childcare centers than in children cared for at home, independent of other possible risk factors.[107,111] Incorporation of conjugated Hib vaccines into the routine immunization schedule of children in the U.S. has reduced dramatically the frequency of invasive Hib disease.[112]

Risk of disease due to *Neisseria meningitidis* may be increased in children in group childcare. Using space–time cluster analysis of invasive infections during 9 years of surveillance, from 1993 to 2001, in the Netherlands, researchers noted that clustering beyond chance occurred at a rate of 3% and concluded that this rate was likely the result of direct transmission. Childcare center attendance was reported as the likely exposure for 8 of 40 (20%) clusters, accounting for 13 of 82 (16%) cases of invasive disease with multiple serosubtypes.[113] For children from 2 through 10 years of age, routine immunization with meningococcal conjugate vaccine is recommended only for children at continued increased risk of invasive disease.[114]

The risks of developing primary invasive disease due to *S. pneumoniae,* nasopharyngeal carriage of *S. pneumoniae,* and carriage of antibiotic-resistant strains are increased for children in childcare centers[115–123] and childcare homes.[117] In Finland, an increased risk of invasive pneumococcal disease in children <2 years of age was associated with childcare attendance (OR, 36; 95% CI, 5.7 to 233) and family childcare (OR, 4.4; 95% CI, 1.7 to 112).[117] Secondary spread of *S. pneumoniae* in the childcare setting has been reported, but the exact risks are not known.[110,122,124–126] Colonization with *S. pneumoniae* in one childcare center was 59% for children 2 to 24 months of age; 75% of the strains were penicillin-nonsusceptible.[118] In an evaluation of the childcare cohort of an 11-month enrollee with multidrug-resistant *S. pneumoniae* infection in southwest Georgia, *S. pneumoniae* was isolated from 19 of 21 (90%) nasopharyngeal cultures; 10 (53%) matched the serotype[14] and susceptibility pattern of the strain from the index child; 4 of the 10 children with index-strain carriage had shared a childcare room with the index child, suggesting person-to-person transmission.[127]

Incorporation of heptavalent pneumococcal conjugate vaccine (PCV7) into the routine childhood immunization schedule in the U.S. in August 2000 has resulted in a dramatic reduction in the frequency of invasive pneumococcal disease (IPD).[128] The impact of vaccination on AOM and reduction of penicillin-nonsusceptible pneumococcal infection is less dramatic and more variable, with evidence of increasing nasopharyngeal colonization and respiratory tract infections caused by nonvaccine serotypes and nontypable strains of pneumococcus.[128–131] Serotype 19A, not included in PCV7, has been associated with IPD in many communities[132] and in childcare.[133] A 13-valent pneumococcal conjugate vaccine (PCV13) was licensed by the Food and Drug Administration (FDA) in 2010 to replace PCV7.[134,135] The impact of broader serotype coverage, including serotype 19A, with PCV13 on epidemiology will be important to monitor as PCV13 is administered to a notable proportion of enrollees in group childcare.

## Viral Infections

### Echovirus

During an outbreak of echovirus 30 infection in children and care providers in a childcare center, and in exposed parents, infection occurred in 75% of children and 60% of adults; aseptic meningitis was more frequent in infected adults (12 in 65, 18%) than in children (2 in 79, 3%).[139] A retrospective cohort study of four childcare centers, attendees, employees, and household contacts in Germany revealed that 42% of childcare attendees, 13% of their household contacts, 5% of childcare center employees, and 2% of their household contacts were ill over a 31-day period. Thirteen percent (12 of 92) of childcare attendees had meningitis. This outbreak likely began among children enrolled in group childcare, with secondary cases occurring among their household contacts.[140] An association with childcare also was noted in an outbreak of echovirus 18 meningitis in a rural Missouri community with an attack rate of 1 per 1000 people; contact with childcare was noted as the most common risk factor among ill people.[141]

### Parvovirus B19

Parvovirus B19, the agent of erythema infectiosum (fifth disease), can cause arthropathy, transient aplastic crisis, persistent anemia

in immunocompromised hosts, and nonimmune fetal hydrops. Serologic evidence of past infection has been reported to be 30% to 60% in adults, 15% to 60% in school-aged children, and 2% to 15% in preschool children.[178] The virus is endemic among young children and has caused outbreaks of disease in the childcare setting.[179,180] Parvovirus B19 spreads by the respiratory route or through contact with oropharyngeal secretions. In an outbreak during which more than 571 school and childcare personnel were tested serologically, the overall attack rate among susceptible individuals was 19%, with the highest rate (31%) occurring in childcare personnel.[179] A cross-sectional study of 477 childcare staff revealed a seroprevalence for parvovirus B19 IgG antibodies of 70%. Seropositivity was associated with age, and among staff less than 40 years of age, with length of group childcare contact.[181] The greatest concern is that an infected pregnant woman could transmit the virus transplacentally, leading to fetal hydrops; neonatal illness and congenital malformations have not been linked to prenatal parvovirus B19 infection. Estimates of the risk of fetal loss when a pregnant woman of unknown antibody status is exposed are 3% for fetal death after household exposure and 2% after occupational exposure in a school.[182]

### Cytomegalovirus

Young childcare attendees shed cytomegalovirus (CMV) chronically after acquisition and often transmit virus to other children and adults with whom they have close daily contact.[142–145] Transmission is thought to occur through direct person-to-person contact and from contaminated toys, hands of childcare providers, or classroom surfaces.[146] Prevalence studies have shown that 10% to 70% of children <3 years of age (peak, 13 through 24 months) in childcare settings have CMV detected in urine or saliva.[142,144,147] CMV-infected children can transmit the virus to women, with rates from 8% to 20% in their childcare providers and 20% in their mothers per year[148–150] compared with rates of 1% to 3% per year in women whose toddlers are not infected.

## Bloodborne Viral Pathogens

There is concern about the potential for spread of bloodborne organisms in the childcare setting: hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV).[151–154] The highest concentrations of HBV in infected people are found in blood and blood-containing body fluids. The most common and efficient routes of transmission are percutaneous blood exposure, sexual exposure, and, perinatally, from mothers to offspring at the time of delivery. Other recognized but less efficient modes of transmission include bites and mucous membrane exposure to blood or other body fluids.[155,156] Two case reports and a larger study have demonstrated possible transmission of HBV among children in the childcare setting.[156–158] Investigators in Denmark and the Netherlands demonstrated high levels of HBV DNA in saliva of 46 HBeAg-positive children, suggesting that exposure to saliva could be a means of horizontal transmission of hepatitis B infection.[159] Other investigators have failed to demonstrate transmission in childcare, despite long-term exposure to children positive for hepatitis B surface antigen (HBsAg).[160] Because of the small number of studies, the risk of HBV transmission in childcare cannot be quantified precisely. With implementation of universal immunization of infants with HBV vaccine beginning in 1991, the potential for horizontal HBV transmission in the childcare setting has been reduced to negligible. If a known HBsAg carrier bites and breaks the skin of an unimmunized child, hepatitis B immune globulin and the HBV vaccine series should be administered.[152] The transmission risk of HCV infection in childcare settings is unknown. The general risk of HCV infection from percutaneous exposure to infected blood is estimated to be 10 times greater than HIV but less than HBV.

No cases of HIV infection are known to have resulted from transmission of the virus in out-of-home childcare. Children with HIV infection in the childcare setting should be monitored for exposure to infectious diseases, and their health and immune status should be evaluated frequently. The risk of transmission of HIV by percutaneous body fluid exposure, such as biting, is low. Complete evaluation of the source and extent of exposure should be undertaken to assess the possible risk of HIV transmission and benefits of postexposure prophylaxis.[152]

Precautions for prevention of HBV, HCV, and HIV infection should be directed toward preventing transfer of blood or secretions from person to person. Childcare providers should be educated about modes of transmission of bloodborne diseases and their prevention, and each center should have written policies for managing illnesses and common injuries[161] such as bite wounds.[162] Standard precautions for handling blood and blood-containing body fluids should be practiced in all childcare settings.[152] Children infected with HIV or HCV or children who are HBsAg carriers should be included in childcare activities. Decisions regarding attendance at childcare and the optimal childcare environment should be made by parents and the child's physician after considering the possible risks and benefits.

## Skin Infection and Infestation

The magnitude of skin infections or infestations and the rates of occurrence in children in group childcare compared with rates in age-matched children not in group childcare are not known. The most frequently recognized nonvaccine-preventable conditions are impetigo or cellulitis (due to *S. aureus* or GAS), pediculosis, and scabies.[88,98,163] Other conditions with skin manifestations that occur in children in childcare include herpes simplex virus (HSV) infection, varicella, ringworm, and molluscum contagiosum.[88,164–166]

### Varicella Zoster

Unimmunized children in childcare facilities are susceptible to varicella infection; most reported cases occur in children <10 years of age.[88,165] An outbreak of varicella was reported when a child with zoster attended a childcare center.[164] Although the lesions were covered, the child continually scratched and showed others the lesions, indicating the potential difficulties with enforcement of preventive policies. Universal immunization with varicella vaccine has reduced cases of chickenpox among children in group childcare.[58,167] However, several outbreaks of varicella have been reported among childcare attendees in the post-licensure era.[89,168,169] A varicella outbreak occurring among elementary school attendees in Maine in December to January 2003 was due to failure to vaccinate. The vaccination rates were notable for a decrease from 90% of kindergarten attendees to 60% of third-grade enrollees. Vaccine effectiveness in this cohort of 296 students was 89% against all varicella disease and 96% against moderate to severe disease. This outbreak illustrates the importance of vaccination of susceptible older children and adolescents to decrease the incidence of severe disease in unvaccinated children.[167] In June 2005 and June 2006, ACIP recommended the implementation of a routine 2-dose varicella vaccination program for children, with the first dose administered at 12 through 15 months and the second dose at 4 through 6 years of age.[167] An outbreak among elementary school student recipients of 1-dose and 2-dose varicella immunizations with a pre-outbreak coverage rate of 97% resulted in 84 reported infections (most cases with <50 lesions). Of these, 25 (30%) of children had received 2 doses and 53 (63%) had received one dose of varicella vaccine. The severity of disease and vaccine effectiveness of 1 and 2 doses were comparable.[170] An outbreak in an elementary school in Philadelphia in 2006 demonstrated that second-dose varicella vaccination for outbreak control was an effective intervention to reduce varicella incidence among classroom contacts of a case.[171–173] This strategy may be employed as a control measure among age-eligible childcare attendees who have not received the 2-dose varicella series in an outbreak setting.

**TABLE 3-3. Vaccine-Preventable Infections**

| | Immunization Indicated | |
|---|---|---|
| **Organism** | **Childcare Attendee** | **Childcare Provider** |
| Diphtheria, pertussis, tetanus | As part of the 5-dose DTaP series | Tdap booster as adolescent and one time dose of Tdap to adults who have not received Tdap then Td every 10 years |
| *Haemophilus influenzae* type b (Hib) | As part of the 3–4-dose series, depending on vaccine used | Not indicated |
| Hepatitis A | 2-dose series beginning at 1 year (12 through 23 months) of age | 2-dose series recommended for adults at high risk for hepatitis A virus infection; not routinely recommended for childcare providers |
| Hepatitis B | 3-dose series beginning at birth | 3-dose series recommended for hepatitis B virus infection; not routinely recommended for childcare providers |
| Influenza A and B | Annual immunization for all children 6 months of age and older; 2 doses if first influenza immunization and ≤8 years of age | Annual immunization with trivalent inactivated or live attenuated influenza vaccine |
| Measles, mumps, rubella | 2-dose series starting at 12 months of age | Booster immunization if only one dose received |
| Meningococcal disease | Conjugate vaccine for children 2 through 10 years of age in high-risk groups and routinely at 11 through 18 years of age for all children and adolescents | Conjugate vaccine recommended for adults 19 through 55 years of age or polysaccharide vaccine for adults ≥56 years of age at increased risk |
| Pneumococcal disease | 4 doses of 13-valent conjugate vaccine (PCV13) for all children 2 through 23 months of age; 1 dose of PCV13 for certain children 24 through 59 months of age. Polysaccharide vaccine in addition to conjugate vaccine for certain high-risk groups 2 through 18 years of age | Pneumococcal polysaccharide vaccine for adults with chronic conditions and for high-risk groups 19 through 64 years of age and all adults at ≥65 years of age |
| Poliomyelitis | 4-dose series; final dose administered at or after the fourth birthday | Most adults are immune; inactivated poliovirus vaccine may be indicated in select populations |
| Rotavirus | 2 or 3-dose series beginning at 2 months of age and completed by 8 months of age | Not indicated |
| Varicella | 2 doses, one at 12 through 15 months of age and the second at 4 through 6 years of age | 2 doses for susceptible people ≥13 years of age |
| Human papillomavirus | 3 doses for females and males 9 years through 26 years of age | 3 doses for females through 26 years of age |

### Herpes Simplex

Clusters of primary HSV infections occur in children in childcare, most frequently manifesting as gingivostomatitis.[166] In one study, restriction endonuclease analysis of DNA of isolated HSV revealed that a single strain of HSV-1 had been transmitted among children.[174] Molluscum contagiosum is a benign, usually asymptomatic viral infection of the skin; humans are the only source. Virus is spread by direct contact or by fomites. Infectivity is low, but outbreaks have been reported. The frequency of occurrence in the childcare setting is unknown. The incidence of pediculosis capitis (head lice) among children in childcare facilities in Seattle was 0.02 per 100 child-weeks[175] and 0.03 per child-year in San Diego.[176] Because head lice are transmitted by direct head-to-head contact, childcare centers with shared sleeping areas may facilitate transmission. Treatment of infested children and their contacts with pediculicides may be considered as control measures.[177]

### Methicillin-Resistant *Staphylococcus aureus*

Infections due to methicillin-resistant *Staphylococcus aureus* (MRSA) were reported infrequently in the group childcare setting before 2000.[136,137] However, with the emergence of community-acquired (CA)-MRSA and its predisposition for affecting people in crowded conditions where sharing of fomites and skin-to-skin contact occurs, and where hygiene is compromised, children in group care are at risk. A molecular epidemiologic study of MRSA prevalence among 104 children, 32 employees, and 17 household contacts of attendees affiliated with a university medical center childcare facility in Texas noted an overall 7% colonization rate with MRSA. MRSA was isolated from one employee (3%), 6 (35%) family members and 4 (2%) environmental samples. Molecular typing revealed closely related, mostly community-associated isolates. The use of macrolide antibiotics and asthma medications were associated with MRSA colonization.[138] MRSA colonization of a child in a childcare setting is not a reason for exclusion from the setting.

## VACCINE-PREVENTABLE DISEASES

In the United States, there are 16 diseases against which children should be immunized, unless there are medical contraindications: diphtheria, tetanus, pertussis, Hib, measles, mumps, rubella, poliomyelitis, HBV, varicella, *S. pneumoniae,* HAV, influenza, rotavirus, human papillomavirus, and meningococcal disease.[58] Immunization of children and their care providers should be high priority (Table 3-3) and immunization especially is likely to benefit children in childcare settings.[183] High levels of immunization exist among children in licensed childcare facilities, partially because laws requiring age-appropriate immunizations of children attending licensed childcare programs exist in almost all states. Vaccine mandates for HBV are active in 47 (94%) states as of June 2010, hepatitis A in 17 (34%) states as of October 2010, pneumococcus in 31 (62%) of states as of October 2010, and varicella in 49 (98%) states as of December 2010 (http://www.immunize.org/laws/#inf). In a study of exemptions to immunizations, children of childcare age (3 through 5 years) with exemptions to immunizations were 66 times more likely to acquire measles and 17 times more likely to acquire pertussis than were age-matched immunized children.[184]

## INFECTIONS ASSOCIATED WITH ANIMALS

Animal exposure has been associated with sporadic zoonotic infections as well as outbreaks, injuries, and allergies, most notably in children <5 years of age. The increased prevalence of infections in

this age group is likely due to compromised hand hygiene resulting in transmission of pathogens from animal to child. Animal interaction can occur in locations where childcare is provided, with a resident pet or visiting animal display, or in public venues where children visit, including petting zoos, aquariums, county fairs, parks, carnivals, circuses, or farms. Guidelines to reduce opportunities for transmission and infection have been developed to prevent disease transmission in many of these settings.[185,186] Inadequate hand hygiene, suboptimal supervision of children's activities following animal contact, and hand-to-mouth activities following animal contact are risk factors for infection. Infections that have been associated with close contact with animals include those caused by *Escherichia coli* O157:H7, *Salmonella enterica* serotype Typhimurium, *Cryptosporidium parvum*, *Campylobacter jejuni*, Shiga toxin-producing *E. coli* (STEC), and *Giardia intestinalis*.[187–190] In addition to enteric infections, animal exposure can result in transmission of ecto- and endoparasites, *Mycobacterium tuberculosis* in certain settings, and local or systemic infections as a consequence of bites, scratches, stings, and other injuries.

Contact with animals within the childcare environment should occur where controls are established to reduce the risk of injuries and disease. Specific recommendations for group childcare settings include close supervision of children during animal contact, strict hand hygiene after direct animal contact or contact with animal products or environment, designation of areas for animal contact that are separate from areas in which food or drink are consumed, disinfection and cleaning of all animal areas with supervision of children >5 years of age who may be participating in this task. Amphibians, reptiles, and weasels (ferrets and mink) should be housed in a cage and not handled by children. Wild or exotic animals, nonhuman primates, mammals with a high risk of transmitting rabies, wolf-dog hybrids, aggressive wild or domestic animals, stray animals, venomous or toxin-producing spiders, and insects should not be permitted in the group childcare setting,[190] (http://www.cdc.gov/healthypets/).

## ANTIBIOTIC USE AND RESISTANCE PATTERNS

During an 8-week period of observation of 270 children, antimicrobial agents were used by 36% of children in childcare centers compared with 7% and 8% of children in childcare homes or in home care, respectively (P<0.001). The mean duration of antibiotic therapy prescribed for children in childcare centers (20 days) differed significantly (P<0.001) from children in childcare homes (4 days) and children in home care (5 days).[128] The estimated annual rates of antibiotic treatment ranged from 2.4 to 3.6 times higher for children in group care compared with children in home care.[191,192] A prospective, population-based survey of 818 families with one or more 18-month-old children from 2002 to 2003 in rural and central Sweden revealed that a high concern about infectious illness was associated with more frequent physician consultations and more prescriptions for antibiotics. Concern for infection was more common in children enrolled in group childcare than children not enrolled in group childcare. Concern about infectious illness was an important determining factor for physician consultation and antibiotic prescriptions. Directed consultations in which providers address parental concerns may result in less antibiotic prescribing with preserved parental satisfaction.[193]

Multiple studies have documented an association of childcare center attendance and colonization or infection due to resistant bacteria, including outbreaks of illness due to resistant *S. pneumoniae*[115,117,119–121,126,194,195] and *S. sonnei*,[22,39,40] as well as colonization due to resistant *H. influenzae*,[196] *E. coli*,[197,198] and MRSA.[137]

## INFECTIOUS DISEASES IN ADULTS

Parents of children who attend a childcare facility and people who provide care to these children have increased risk of acquiring infections such as CMV,[143,144,146,147,199–201] parvovirus B19,[179,180] HAV,[202,203] and diarrhea.[44,50] Childcare providers have annual rates of CMV seroconversion ranging between 8% and 20%, compared with hospital employees whose seroconversion rate is about 2%.[143,144,147,201] During community outbreaks of erythema infectiosum, childcare providers were found to be among the most affected occupational groups, with seroconversion rates ranging from 9% to 31%.[179,180] In a prevalence study of HAV antibodies among childcare providers employed in 37 randomly selected childcare centers in Israel during 1997, 90% (402 of 446) of the childcare providers had HAV antibodies; the authors postulated a 2-fold increased risk of acquiring HAV among providers.[203] During outbreaks of diarrhea in childcare centers, 40% of care providers developed diarrhea.[50] During a multicommunity outbreak of shigellosis, the overall median attack rate among employed staff of childcare centers was 6%, with a range of 0% to 17%.[38] In outbreaks of GAS and echovirus 30 infection[139] in childcare centers, adult providers and parents were affected. Similar prevalence rates of pneumococcal colonization (5% among adult employees of childcare centers with child contact and 5% among nonclinical employees at a tertiary care center) were noted in a study performed in 2003 in Galveston, Texas; these data suggest that childcare providers are not at an increased risk for pneumococcal colonization in the universal pneumococcal conjugate vaccine era.[204] Compared with nonproviders childcare providers have a significantly higher annual risk of at least one infectious disease and loss of work days due to infectious diseases.[205] Childcare providers should receive all immunizations routinely recommended for adults, as shown on the adult immunization schedule (see Table 3-3) (www.cdc.gov/vaccines).

## ECONOMIC IMPACT OF GROUP CHILDCARE ILLNESS

The economic burden of illness associated with group childcare was estimated at $1.5 billion annually adjusted to 2005 U.S. dollars.[206] Precise mechanisms for estimating illness burden and for evaluating effectiveness of infection control interventions are rare due to multiple challenges associated with performing such assessments.[207] Attributing an outbreak to group childcare is challenging, because although these settings may promote transmission of infection, childcare attendees and staff interact with household contacts external to the childcare arrangement, thus facilitating secondary spread. A prospective evaluation of 208 families with at least one childcare enrollee, conducted from November 2000 to May 2001 in the Boston area, documented 2072 viral illnesses over 105,352 person-days. Among the 834 subjects, 1683 URTIs and 389 gastrointestinal tract (GI) illnesses were reported during the study period, with a total mean cost of $49 per URTI and $56 per GI episode. Decreased parental productivity during missed days of work to care for a child who had to be withdrawn from childcare accounted for a significant proportion of the nonmedical cost.[206]

## PREVENTION

Specific standards should be established for personal hygiene, especially hand hygiene, maintenance of current immunization records of children and providers, exclusion policies, targeting frequently contaminated areas for environmental cleaning, and appropriate handling of food and medication. In studies in which improved infection control measures were implemented and monitored, both upper respiratory tract illness and diarrhea were reduced in intervention centers.[97,208] In addition, in children at intervention centers, 24% children were given fewer antibiotic prescriptions and parents had fewer absences from work.[98]

Educational sessions on health topics by healthcare professionals were found to be the most efficacious means of promoting health education in simultaneous surveys of licensed childcare center directors, parents, and health providers in Boston.[209] A prospective observational study of a convenience sample of 134 childcare centers in Pennsylvania noted that sites that were located in suburban, non-profit, parent-funded centers had improved health and safety practices compared with sites that were located in urban areas, received their funding through state subsidies, or

were designated as for profit.[210] However, the translation of knowledge into continued practice beyond the education and focus on the intervention remains a challenge. A cross-sectional survey conducted in 2000 childcare providers, parents, and pediatricians in Baltimore revealed deficits of knowledge among all groups. Compared with national guidelines on exclusion for 12 symptoms, childcare providers and parents were over exclusive and pediatricians were under exclusive. More childcare providers and parents than pediatricians felt that exclusion would reduce transmission of disease.[211]

As asymptomatic excretion and potential for transmission precede the onset of clinical symptoms in many childcare-associated infectious diseases, strategies that involve prevention would be most efficacious. In addition to traditional handwashing, the use of alcohol-based hand-sanitizing products in healthcare and other settings is an efficacious means of achieving hand hygiene.[212] Ethanol hand sanitizers are more effective than handwashing with soap and water in removing detectable rhinovirus from hands of adult volunteers. An additional evaluation of the effectiveness of adding organic acids to hand sanitizers was notable for residual rhinovirus virucidal activity of up to 4 hours.[213] In support of this preventive strategy, a cluster-randomized, controlled trial was conducted in the homes of 292 families with children who were enrolled in out-of-home childcare centers. A multifactorial intervention emphasizing alcohol-based hand sanitizer use in the home reduced transmission of GI illnesses within families. The effect on reduction of respiratory tract illness transmission in this evaluation was less pronounced and may relate to use of hand-sanitizing gel following toilet use but not following sneezing, coughing, or blowing/wiping of nasal secretions.[214] A follow-up study that added surface disinfection to a hand sanitizer intervention in a school-based cluster-randomized controlled trial demonstrated a greater decrease in adjusted absenteeism rates due to GI compared with respiratory tract illness. Norovirus was the only virus isolated more frequently from classroom surfaces in the control group.[215] A comparative evaluation of antibacterial liquid soap and alcohol-based hand sanitizer for inactivation of norovirus on human finger pads demonstrated a greater virucidal effectiveness with the antibacterial soap compared to the ethanol-based hand sanitizer. Despite utility of alcohol-based sanitizers for control of enteric and respiratory tract pathogen transmission, they may be relatively ineffective against norovirus.[216] Molecular techniques, including DNA probes, could be used as surrogate markers to study transmission of enteric pathogens in childcare centers and from centers to children's homes.[217] Further evaluations of molecular techniques during outbreak investigations, hand hygiene strategies, and educational interventions could assist with allocation of resources to the most effective prevention regimens.

Written policies should be available for the following areas: managing child and employee illness, including exclusion policies; maintaining health, including immunizations; diaper-changing procedures; hand hygiene; personal hygiene policies for staff and children; environmental sanitation policies and procedures; handling, serving, and preparation of food; dissemination of information about illness; and handling of animals. Local health authorities should be notified about cases of communicable diseases involving children or care providers in the childcare setting. The AAP and the American Public Health Association jointly published the National Health and Safety Performance Standards: Guidelines for Out-of-Home Childcare Programs, available at http://nrckids.org. This comprehensive manual provides guidelines regarding infectious diseases and other health-related matters pertinent to out-of-home childcare. Additional resources include information about group childcare infection rates[218] and guidance for preparation of childcare programs for pandemic response (http://www.aap.org/disasters/).

Future investigation of outbreaks of illness associated with group childcare will need to utilize newly developed computerized models and paradigms to assess the economic impact of outbreaks. In an era of limited funding, an understanding of expenses and allocation of resources will be important information to justify utility of interventions.

## REFERENCES


1. Osterholm MT, Reves RR, Murph JR, Pickering LK. Infectious diseases and child day care. Pediatr Infect Dis J 1992;11(8 Suppl):S31–S41.
2. Pickering LK, Morrow AL. Contagious diseases of child day care. Infection 1991;19:61–63.
3. Carabin H, Gyorkos TW, Soto JC, et al. Estimation of direct and indirect costs because of common infections in toddlers attending day care centers. Pediatrics 1999;103:556–564.
4. Reves RR, Morrow AL, Bartlett AV, et al. Child day care increases the risk of clinic visits for acute diarrhea and diarrhea due to rotavirus. Am J Epidemiol 1993;137:97–107.
5. Staat MA, Morrow AL, Reves RR, et al. Diarrhea in children newly enrolled in day-care centers in Houston. Pediatr Infect Dis J 1991;10:282–286.
6. Collet JP, Burtin P, Kramer MS, et al. Type of day-care setting and risk of repeated infections. Pediatrics 1994;94(6 Pt 2): 997–999.
7. Holberg CJ, Wright AL, Martinez FD, et al. Child day care, smoking by caregivers, and lower respiratory tract illness in the first 3 years of life. Group Health Medical Associates. Pediatrics 1993;91:885–892.
8. Ball TM, Castro-Rodriguez JA, Griffith KA, et al. Siblings, day-care attendance, and the risk of asthma and wheezing during childhood. N Engl J Med 2000;343:538–543.
9. Rusconi F, Galassi C, Corbo GM, et al. Risk factors for early, persistent, and late-onset wheezing in young children. SIDRIA Collaborative Group. Am J Respir Crit Care Med 1999;160(5 Pt 1):1617–1622.
10. Copenhaver CC, Gern JE, Li Z, et al. Cytokine response patterns, exposure to viruses, and respiratory infections in the first year of life. Am J Respir Crit Care Med 2004;170:175–180.
11. Côté SM, Petitclerc A, Raynault MF, et al. Short- and long-term risk of infections as a function of group child care attendance: an 8-year population-based study. Arch Pediatr Adolesc Med 2010;164:1132–1137.
12. Brims F, Chauhan AJ. Air quality, tobacco smoke, urban crowding and day care: modern menaces and their effects on health. Pediatr Infect Dis J 2005;24(11 Suppl):S152–S156, discussion S6–7.
13. Caudri D, Wijga A, Scholtens S, et al. Early daycare is associated with an increase in airway symptoms in early childhood but is no protection against asthma or atopy at 8 years. Am J Respir Crit Care Med 2009;180:491–498.
14. United States Census Bureau USC. A Child's Day: 2006 (Selected Indicators of of Child Well-Being, March 2009). 2009.
15. O'Ryan ML, Matson DO, Estes MK, et al. Molecular epidemiology of rotavirus in children attending day care centers in Houston. J Infect Dis 1990;162:810–816.
16. Pickering L (ed). Bacterial and Parasitic Enteropathogens in Day Care. Philadelphia, WB Saunders, 1990.
17. Bower JR, Congeni BL, Cleary TG, et al. *Escherichia coli* O114:nonmotile as a pathogen in an outbreak of severe diarrhea associated with a day care center. J Infect Dis 1989;160:243–247.
18. Belongia EA, Osterholm MT, Soler JT, et al. Transmission of *Escherichia coli* O157:H7 infection in Minnesota child day-care facilities. JAMA 1993;269:883–888.
19. Paulozzi LJ, Johnson KE, Kamahele LM, et al. Diarrhea associated with adherent enteropathogenic *Escherichia coli* in an infant and toddler center, Seattle, Washington. Pediatrics 1986;77:296–300.
20. Kim K, DuPont HL, Pickering LK. Outbreaks of diarrhea associated with *Clostridium difficile* and its toxin in day-care centers: evidence of person-to-person spread. J Pediatr 1983;102:376–382.
21. Matson DO, Estes MK, Tanaka T, et al. Asymptomatic human calicivirus infection in a day care center. Pediatr Infect Dis J 1990;9:190–196.
22. Brian MJ, Van R, Townsend I, et al. Evaluation of the molecular epidemiology of an outbreak of multiply resistant *Shigella sonnei* in a day-care center by using pulsed-field gel electrophoresis and plasmid DNA analysis. J Clin Microbiol 1993;31:2152–2156.
23. Mitchell DK, Van R, Morrow AL, et al. Outbreaks of astrovirus gastroenteritis in day care centers. J Pediatr 1993;123:725–732.
24. Mitchell DK, Monroe SS, Jiang X, et al. Virologic features of an astrovirus diarrhea outbreak in a day care center revealed by reverse transcriptase-polymerase chain reaction. J Infect Dis 1995;172:1437–1444.
25. Gouveia S, Proctor ME, Lee MS, et al. Genomic comparisons and Shiga toxin production among *Escherichia coli* O157:H7 isolates from a day care center outbreak and sporadic cases in southeastern Wisconsin. J Clin Microbiol 1998;36:727–733.
26. Pickering LK, Evans DG, DuPont HL, et al. Diarrhea caused by *Shigella*, rotavirus, and *Giardia* in day-care centers: prospective study. J Pediatr 1981;99:51–56.
27. Pickering LK, Woodward WE, DuPont HL, Sullivan P. Occurrence of *Giardia lamblia* in children in day care centers. J Pediatr 1984;104:522–526.
28. Centers for Disease Control and Prevention. Recommendations for diagnosis of shiga-toxin producing *Escherichia coli* infections by clinical laboratories. MMWR 2009;58(RR-12):1–14.
29. Raffaelli RM, Paladini M, Hanson H, et al. Child care-associated outbreak of *Escherichia coli* O157:H7 and hemolytic uremic syndrome. Pediatr Infect Dis J 2007;26:951–953.
30. Van R, Morrow AL, Reves RR, Pickering LK. Environmental contamination in child day-care centers. Am J Epidemiol 1991;133:460–470.
31. Van R, Wun CC, Morrow AL, Pickering LK. The effect of diaper type and overclothing on fecal contamination in day-care centers. JAMA 1991;265:1840–1844.
32. Wilde J, Van R, Pickering L, et al. Detection of rotaviruses in the day care environment by reverse transcriptase polymerase chain reaction. J Infect Dis 1992;166:507–511.
33. Rosenfeldt V, Vesikari T, Pang XL, et al. Viral etiology and incidence of acute gastroenteritis in young children attending day-care centers. Pediatr Infect Dis J 2005;24:962–965.
34. Lyman WH, Walsh JF, Kotch JB, et al. Prospective study of etiologic agents of acute gastroenteritis outbreaks in child care centers. J Pediatr 2009;154:253–257.
35. Centers for Disease Control and Prevention. *Bacillus cereus* food poisoning associated with fried rice at two child day care centers – Virginia, 1993. MMWR 1994;43:177–179.
36. Public Health Agency of Canada. Investigation of an *E.coli* O157:H7 outbreak in Brooks, Alberta, June-July 2002: the role of occult spread of infection within a daycare setting. 2003.
37. Garrett V, Bornschlegel K, Lange D, et al. A recurring outbreak of *Shigella sonnei* among traditionally observant Jewish children in New York City: the risks of daycare and household transmission. Epidemiol Infect 2006;134:1231–1236.
38. Shane AL, Tucker NA, Crump JA, et al. Sharing *Shigella:* risk factors for a multicommunity outbreak of shigellosis. Arch Pediatr Adolesc Med 2003;157:601–603.
39. Centers for Disease Control and Prevention. Day care-related outbreaks of rhamnose-negative *Shigella sonnei* – six states, June 2001. MMWR 2004;53:60–65.

40. Arvelo W, Hinkle CJ, Nguyen TA, et al. Transmission risk factors and treatment of pediatric shigellosis during a large daycare center-associated outbreak of multidrug resistant *Shigella sonnei:* implications for the management of shigellosis outbreaks among children. Pediatr Infect Dis J 2009;28:976–980.
41. Kotch JB, Isbell P, Weber DJ, et al. Hand-washing and diapering equipment reduces disease among children in out-of-home child care centers. Pediatrics 2007;120:e29–36.
42. Perry S, de la Luz Sanchez M, et al. Household transmission of gastroenteritis. Emerg Infect Dis 2005;11:1093–1096.
43. Van R, Wun CC, O'Ryan ML, et al. Outbreaks of human enteric adenovirus types 40 and 41 in Houston day care centers. J Pediatr 1992;120(4 Pt 1):516–521.
44. Pickering LK, Bartlett AV, Reves RR, Morrow A. Asymptomatic excretion of rotavirus before and after rotavirus diarrhea in children in day care centers. J Pediatr 1988;112:361–365.
45. Rauch AM, Van R, Bartlett AV, Pickering LK. Longitudinal study of *Giardia lamblia* infection in a day care center population. Pediatr Infect Dis J 1990;9:186–189.
46. Crawford FG, Vermund SH, Ma JY, Deckelbaum RJ. Asymptomatic cryptosporidiosis in a New York City day care center. Pediatr Infect Dis J 1988;7:806–807.
47. Davies AP, Campbell B, Evans MR, et al. Asymptomatic carriage of protozoan parasites in children in day care centers in the United Kingdom. Pediatr Infect Dis J 2009;28:838–840.
48. Alexander CS, Zinzeleta EM, Mackenzie EJ, et al. Acute gastrointestinal illness and child care arrangements. Am J Epidemiol 1990;131:124–131.
49. Bartlett AV, Moore M, Gary GW, et al. Diarrheal illness among infants and toddlers in day care centers. II. Comparison with day care homes and households. J Pediatr 1985;107:503–509.
50. Sullivan P, Woodward WE, Pickering LK, DuPont HL. Longitudinal study of occurrence of diarrheal disease in day care centers. Am J Public Health 1984;74:987–991.
51. Centers for Disease Control and Prevention. Reduction in rotavirus after vaccine introduction – United States, 2000–2009 MMWR 2009;58:1146–1149.
52. Tate JE, Cortese MM, Payne DC, et al. Uptake, impact, and effectiveness of rotavirus vaccination in the United States: review of the first 3 years of postlicensure data. Pediatr Infect Dis J 2011;30(1 Suppl):S56–S60.
53. Centers for Disease Control and Prevention. Prevention of rotavirus gastroenteritis among infants and children: Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR 2009;58(RR-02):1–25.
54. Gehlbach SH, MacCormack JN, Drake BM, Thompson WV. Spread of disease by fecal-oral route in day nurseries. Health Serv Rep 1973;88:320–322.
55. Shapiro C (ed). Significance of hepatitis in children in day care. Philadelphia, WB Saunders, 1990.
56. Hadler SC, Erben JJ, Francis DP, et al. Risk factors for hepatitis A in day-care centers. J Infect Dis 1982;145:255–261.
57. Belmaker I, Dukhan L, Yosef Y, et al. Elimination of hepatitis a infection outbreaks in day care and school settings in southern Israel after introduction of the national universal toddler hepatitis a immunization program. Pediatr Infect Dis J 2007;26:36–40.
58. Centers for Disease Control and Prevention. Recommended immunization schedules for persons aged 0 through 18 years – United States, 2011. MMWR 2011;60:1–4.
59. Centers for Disease Control and Prevention. Update: Prevention of hepatitis A after exposure to hepatitis a virus and in international travelers. Updated Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR 2007;56:1080–1084.
60. Victor JC, Monto AS, Surdina TY, et al. Hepatitis A vaccine versus immune globulin for postexposure prophylaxis. N Engl J Med 2007;357:1685–1694.
61. Duggirala HJ, Hassig SE, Santana S, Rice J. Evaluation of a hepatitis A immunization program. Pediatr Infect Dis J 2005;24:974–978.
62. Louhiala PJ, Jaakkola N, Ruotsalainen R, Jaakkola JJ. Form of day care and respiratory infections among Finnish children. Am J Public Health 1995;85(8 Pt 1):1109–1112.
63. Celedon JC, Litonjua AA, Weiss ST, Gold DR. Day care attendance in the first year of life and illnesses of the upper and lower respiratory tract in children with a familial history of atopy. Pediatrics 1999;104(3 Pt 1):495–500.
64. Hurwitz ES, Gunn WJ, Pinsky PF, Schonberger LB. Risk of respiratory illness associated with day-care attendance: a nationwide study. Pediatrics 1991;87:62–69.
65. Nafstad P, Hagen JA, Oie L, et al. Day care centers and respiratory health. Pediatrics 1999;103(4 Pt 1):753–758.
66. Wald ER, Guerra N, Byers C. Frequency and severity of infections in day care: three-year follow-up. J Pediatr 1991;118(4 Pt 1):509–514.
67. Fairchok MP, Martin ET, Chambers S, et al. Epidemiology of viral respiratory tract infections in a prospective cohort of infants and toddlers attending daycare. J Clin Virol 2010;49:16–20.
68. Montejano-Elías L, Alpuche-Solís AG, Zárate-Chávez V, et al. Human metapneumovirus and other respiratory viral infections in children attending a day care center. Pediatr Infect Dis J 2009;28:1024–1026.
69. Martin ET, Fairchok MP, Kuypers J, et al. Frequent and prolonged shedding of bocavirus in young children attending daycare. J Infect Dis 2010;201:1625–1632.
70. Kamper-Jørgensen M, Wohlfahrt J, Simonsen J, et al. Population-based study of the impact of childcare attendance on hospitalizations for acute respiratory infections. Pediatrics 2006;118:1439–1446.
71. Wald ER, Dashefsky B, Byers C, et al. Frequency and severity of infections in day care. J Pediatr 1988;112:540–546.
72. Centers for Disease Control and Prevention. Recommended antimicrobial agents for the treatment and postexposure prophylaxis of pertussis. MMWR 2005;54(RR-14):1–16.
73. American Academy of Pediatrics, Committee on Infectious Diseases. Prevention of pertussis among adolescents: recommendations for use of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine. Pediatrics 2006;117:965–978.
74. Centers for Disease Control and Prevention. Updated recommendations for use of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine from the ACIP. MMWR 2011;60:13–15.
75. Centers for Disease Control and Prevention. Notes from the field: pertussis – California, January – June 2010 MMWR 2010;59:817.
76. Hochwald O, Bamberger ES, Rubin L, et al. A pertussis outbreak among daycare children in Northern Israel: who gets sick? Isr Med Assoc J 2010;12:283–286.
77. Centers for Disease Control and Prevention. Additional recommendations for use of Tdap. MMWR 2011;60:13–16.
78. Driver CR, Jones JS, Cavitt L, et al. Tuberculosis in a day-care center, Kentucky, 1993. Pediatr Infect Dis J 1995;14:612–616.
79. Leggiadro RJ, Callery B, Dowdy S, Larkin J. An outbreak of tuberculosis in a family day care home. Pediatr Infect Dis J 1989;8:52–54.
80. Dewan PK, Banouvong H, Abernethy N, et al. A tuberculosis outbreak in a private-home family child care center in San Francisco, 2002 to 2004. Pediatrics 2006;117:863–869.

81. Gillman A, Berggren I, Bergström SE, et al. Primary tuberculosis infection in 35 children at a Swedish day care center. Pediatr Infect Dis J 2008;27:1078–1082.
82. Wolf JE, Dean JL. Risk of tuberculosis transmission in an adult day-care center. Infect Control Hosp Epidemiol 1999;20:157–158.
83. Normann E, Gnarpe J, Gnarpe H, Wettergren B. *Chlamydia pneumoniae* in children attending day-care centers in Gävle, Sweden. Pediatr Infect Dis J 1998;17:474–478.
84. Slonim A, Walker ES, Mishori E, et al. Person-to-person transmission of *Kingella kingae* among day care center attendees. J Infect Dis 1998;178:1843–1846.
85. Kiang KM, Ogunmodede F, Juni BA, et al. Outbreak of osteomyelitis/septic arthritis caused by *Kingella kingae* among child care center attendees. Pediatrics 2005;116:e206–e213.
86. Seña AC, Seed P, Nicholson B, et al. *Kingella kingae* endocarditis and a cluster investigation among daycare attendees. Pediatr Infect Dis J 2010;29:86–88.
87. Engelgau MM, Woernle CH, Schwartz B, et al. Invasive group A *Streptococcus* carriage in a child care centre after a fatal case. Arch Dis Child 1994;71:318–322.
88. Centers for Disease Control and Prevention. Outbreak of invasive group A *Streptococcus* associated with varicella in a childcare center – Boston, Massachusetts 1997. MMWR 1997;46:944–948.
89. Galil K, Lee B, Strine T, et al. Outbreak of varicella at a day-care center despite vaccination. N Engl J Med 2002;347:1909–1915.
90. Yagupsky P, Landau D, Beck A, Dagan R. Carriage of *Streptococcus pyogenes* among infants and toddlers attending day-care facilities in closed communities in southern Israel. Eur J Clin Microbiol Infect Dis 1995;14:54–58.
91. Aguero J, Ortega-Mendi M, Eliecer Cano M, et al. Outbreak of invasive group A streptococcal disease among children attending a day-care center. Pediatr Infect Dis J 2008;27:602–604.
92. Zeisel SA, Roberts JE, Gunn EB, et al. Prospective surveillance for otitis media with effusion among black infants in group child care. J Pediatr 1995;127:875–880.
93. Marx J, Osguthorpe JD, Parsons G. Day care and the incidence of otitis media in young children. Otolaryngol Head Neck Surg 1995;112:695–699.
94. Daly K, Giebink GS, Le CT, et al. Determining risk for chronic otitis media with effusion. Pediatr Infect Dis J 1988;7:471–475.
95. Barbosa-Cesnik C, Farjo RS, et al. Predictors for *Haemophilus influenzae* colonization, antibiotic resistance and for sharing an identical isolate among children attending 16 licensed day-care centers in Michigan. Pediatr Infect Dis J 2006;25:219–223.
96. Sá-Leão R, Nunes S, Brito-Avô A, et al. High rates of transmission of and colonization by *Streptococcus pneumoniae* and *Haemophilus influenzae* within a day care center revealed in a longitudinal study. J Clin Microbiol 2008;46:225–234.
97. Roberts L, Smith W, Jorm L, et al. Effect of infection control measures on the frequency of upper respiratory infection in child care: a randomized, controlled trial. Pediatrics 2000;105(4 Pt 1):738–742.
98. Uhari M, Möttönen M. An open randomized controlled trial of infection prevention in child day-care centers. Pediatr Infect Dis J 1999;18:672–677.
99. Centers for Disease Control and Prevention. Prevention and Control of Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010. MMWR 2010;59(RR-08):1–62.
100. Hurwitz ES, Haber M, Chang A, et al. Studies of the 1996–1997 inactivated influenza vaccine among children attending day care: immunologic response, protection against infection, and clinical effectiveness. J Infect Dis 2000;182:1218–1221.
101. Hurwitz ES, Haber M, Chang A, et al. Effectiveness of influenza vaccination of day care children in reducing influenza-related morbidity among household contacts. JAMA 2000;284:1677–1682.
102. Pisu M, Meltzer MI, Hurwitz ES, Haber M. Household-based costs and benefits of vaccinating healthy children in daycare against influenza virus: results from a pilot study. Pharmacoeconomics 2005;23:55–67.
103. Heikkinen T, Ruuskanen O, Waris M, et al. Influenza vaccination in the prevention of acute otitis media in children. Am J Dis Child 1991;145:445–448.
104. Clements DA, Langdon L, Bland C, Walter E. Influenza A vaccine decreases the incidence of otitis media in 6- to 30-month-old children in day care. Arch Pediatr Adolesc Med 1995;149:1113–1117.
105. Luce BR, Zangwill KM, Palmer CS, et al. Cost-effectiveness analysis of an intranasal influenza vaccine for the prevention of influenza in healthy children. Pediatrics 2001;108:E24.
106. Reichert TA, Sugaya N, Fedson DS, et al. The Japanese experience with vaccinating schoolchildren against influenza. N Engl J Med 2001;344:889–896.
107. Osterholm M (ed). Invasive bacterial diseases and child day care. Philadelphia, WB Saunders, 1990.
108. Pappas DE, Hendley JO, Schwartz RH. Respiratory viral RNA on toys in pediatric office waiting rooms. Pediatr Infect Dis J 2010;29:102–104.
109. Effler PV, Carcione D, Giele C, et al. Household responses to pandemic (H1N1) 2009-related school closures, Perth, Western Australia. Emerg Infect Dis 2010;16:205–211.
110. McCormick JB, Yan C, Ballou J, et al. Response to H1N1 in a U.S.-Mexico border community. Biosecur Bioterror 2010;8:233–242.
111. Berg AT, Shapiro ED, Capobianco LA. Group day care and the risk of serious infectious illnesses. Am J Epidemiol 1991;133:154–163.
112. Adams WG, Deaver KA, Cochi SL, et al. Decline of childhood *Haemophilus influenzae* type b (Hib) disease in the Hib vaccine era. JAMA 1993;269:221–226.
113. Hoebe CJ, de Melker H, Spanjaard L, et al. Space-time cluster analysis of invasive meningococcal disease. Emerg Infect Dis 2004;10:1621–1626.
114. CDC. Updated recommendations from the ACIP for revaccination of persons at prolonged risk for meningococcal disease. MMWR 2009;58:1042–1043.
115. Gessner BD, Ussery XT, Parkinson AJ, Breiman RF. Risk factors for invasive disease caused by *Streptococcus pneumoniae* among Alaska native children younger than two years of age. Pediatr Infect Dis J 1995;14:123–128.
116. American Academy of Pediatrics. Committee on Infectious Diseases. Policy statement: recommendations for the prevention of pneumococcal infections, including the use of pneumococcal conjugate vaccine (Prevnar), pneumococcal polysaccharide vaccine, and antibiotic prophylaxis. Pediatrics 2000;106(2 Pt 1):362–366.
117. Takala AK, Jero J, Kela E, et al. Risk factors for primary invasive pneumococcal disease among children in Finland. JAMA 1995;273:859–864.
118. Boken DJ, Chartrand SA, Goering RV, et al. Colonization with penicillin-resistant *Streptococcus pneumoniae* in a child-care center. Pediatr Infect Dis J 1995;14:879–884.
119. Levine OS, Farley M, Harrison LH, et al. Risk factors for invasive pneumococcal disease in children: a population-based case-control study in North America. Pediatrics 1999;103:E28.
120. Givon-Lavi N, Dagan R, Fraser D, et al. Marked differences in pneumococcal carriage and resistance patterns between day

care centers located within a small area. Clin Infect Dis 1999;29:1274–1280.
121. Kellner JD, Ford-Jones EL. *Streptococcus pneumoniae* carriage in children attending 59 Canadian child care centers. Toronto Child Care Centre Study Group. Arch Pediatr Adolesc Med 1999;153:495–502.
122. Craig AS, Erwin PC, Schaffner W, et al. Carriage of multidrug-resistant *Streptococcus pneumoniae* and impact of chemoprophylaxis during an outbreak of meningitis at a day care center. Clin Infect Dis 1999;29:1257–1264.
123. Centers for Disease Control and Prevention. Licensure of a 13-Valent Pneumococcal Conjugate Vaccine (PCV13) and Recommendations for Use Among Children – Advisory Committee on Immunization Practices (ACIP). MMWR 2010;59;258–261.
124. Rauch AM, O'Ryan M, Van R, Pickering LK. Invasive disease due to multiply resistant *Streptococcus pneumoniae* in a Houston, Tex, day-care center. Am J Dis Child 1990;144:923–927.
125. Reichler MR, Allphin AA, Breiman RF, et al. The spread of multiply resistant *Streptococcus pneumoniae* at a day care center in Ohio. J Infect Dis 1992;166:1346–1353.
126. Cherian T, Steinhoff MC, Harrison LH, et al. A cluster of invasive pneumococcal disease in young children in child care. JAMA 1994;271:695–697.
127. Centers for Disease Control and Prevention. Multidrug-resistant *Streptococcus pneumoniae* in a child care center – Southwest Georgia, December 2000. MMWR 2002;50;1156–1158.
128. Schutze GE, Tucker NC, Mason EO. Impact of the conjugate pneumococcal vaccine in arkansas. Pediatr Infect Dis J 2004;23:1125–1129.
129. McEllistrem MC, Adams JM, Patel K, et al. Acute otitis media due to penicillin-nonsusceptible *Streptococcus pneumoniae* before and after the introduction of the pneumococcal conjugate vaccine. Clin Infect Dis 2005;40:1738–1744.
130. Frazão N, Brito-Avô A, Simas C, et al. Effect of the seven-valent conjugate pneumococcal vaccine on carriage and drug resistance of *Streptococcus pneumoniae* in healthy children attending day-care centers in Lisbon. Pediatr Infect Dis J 2005;24:243–252.
131. Sousa NG, Sá-Leão R, Crisóstomo MI, et al. Properties of novel international drug-resistant pneumococcal clones identified in day-care centers of Lisbon, Portugal. J Clin Microbiol 2005;43:4696–4703.
132. Kaplan SL, Barson WJ, Lin PL, et al. Serotype 19A Is the most common serotype causing invasive pneumococcal infections in children. Pediatrics 2010;125:429–436.
133. Shouval DS, Porat N, Dagan R, et al. Bacteremia caused by a highly-resistant *Streptococcus pneumoniae* serotype 19A circulating in a daycare center. Int J Infect Dis 2010;14(Suppl 3):e253–e255.
134. Centers for Disease Control and Prevention. Prevention of pneumococcal disease among infants and childrem – use of 13-valent pneumococcal conjugate vaccine and 23-valent pneumococcal polysaccharide vaccine – Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR 2010;59(RR-11):1–18.
135. Yeh SH, Gurtman A, Hurley DC, et al. Immunogenicity and safety of 13-valent pneumococcal conjugate vaccine in infants and toddlers. Pediatrics 2010;126:e493–505.
136. Shahin R, Johnson IL, Jamieson F, et al. Methicillin-resistant *Staphylococcus aureus* carriage in a child care center following a case of disease. Toronto Child Care Center Study Group. Arch Pediatr Adolesc Med 1999;153:864–868.
137. Adcock PM, Pastor P, Medley F, et al. Methicillin-resistant *Staphylococcus aureus* in two child care centers. J Infect Dis 1998;178:577–580.
138. Hewlett AL, Falk PS, Hughes KS, Mayhall CG. Epidemiology of methicillin-resistant *Staphylococcus aureus* in a university medical center day care facility. Infect Control Hosp Epidemiol 2009;30:985–992.
139. Helfand RF, Khan AS, Pallansch MA, et al. Echovirus 30 infection and aseptic meningitis in parents of children attending a child care center. J Infect Dis 1994;169:1133–1137.
140. Vieth UC, Kunzelmann M, Diedrich S, et al. An echovirus 30 outbreak with a high meningitis attack rate among children and household members at four day-care centers. Eur J Epidemiol 1999;15:655–658.
141. Turabelidze G, Lin M, Butler C, et al. Outbreak of echovirus 18 meningitis in a rural Missouri community. Mo Med 2009;106:420–424.
142. Adler SP. Molecular epidemiology of cytomegalovirus: viral transmission among children attending a day care center, their parents, and caretakers. J Pediatr 1988;112:366–372.
143. Adler SP. Cytomegalovirus and child day care: evidence for an increased infection rate among day-care workers. N Engl J Med 1989;321:1290–1296.
144. Pass R (ed). Day care centers and transmission of cytomegalovirus: new insight into an old problem. Philadelphia, WB Saunders, 1990.
145. Joseph SA, Béliveau C, Muecke CJ, et al. Cytomegalovirus as an occupational risk in daycare educators. Paediatr Child Health 2006;11:401–407.
146. Hutto C, Little EA, Ricks R, et al. Isolation of cytomegalovirus from toys and hands in a day care center. J Infect Dis 1986;154:527–530.
147. Ford-Jones EL, Kitai I, Davis L, et al. Cytomegalovirus infections in Toronto child-care centers: a prospective study of viral excretion in children and seroconversion among day-care providers. Pediatr Infect Dis J 1996;15:507–514.
148. Adler SP. Cytomegalovirus transmission among children in day care, their mothers and caretakers. Pediatr Infect Dis J 1988;7:279–285.
149. Pass RF, Hutto C, Lyon MD, Cloud G. Increased rate of cytomegalovirus infection among day care center workers. Pediatr Infect Dis J 1990;9:465–470.
150. Murph JR, Baron JC, Brown CK, et al. The occupational risk of cytomegalovirus infection among day-care providers. JAMA 1991;265:603–608.
151. Rogers MF, White CR, Sanders R, et al. Lack of transmission of human immunodeficiency virus from infected children to their household contacts. Pediatrics 1990;85:210–214.
152. Havens PL, AIDS AAoPCoP. Postexposure prophylaxis in children and adolescents for nonoccupational exposure to human immunodeficiency virus. Pediatrics 2003;111(6 Pt 1): 1475–1489.
153. Morrow AL, Benton M, Reves RR, Pickering LK. Knowledge and attitudes of day care center parents and care providers regarding children infected with human immunodeficiency virus. Pediatrics 1991;87:876–883.
154. Simonds RJ, Chanock S. Medical issues related to caring for human immunodeficiency virus-infected children in and out of the home. Pediatr Infect Dis J 1993;12:845–852.
155. Cancio-Bello TP, de Medina M, Shorey J, et al. An institutional outbreak of hepatitis B related to a human biting carrier. J Infect Dis 1982;146:652–656.
156. Shapiro CN, McCaig LF, Gensheimer KF, et al. Hepatitis B virus transmission between children in day care. Pediatr Infect Dis J 1989;8:870–875.
157. Nigro G, Taliani G. Nursery-acquired asymptomatic B hepatitis. Lancet 1989;1(8652):1451–1452.
158. Hayashi J, Kashiwagi S, Nomura H, et al. Hepatitis B virus transmission in nursery schools. Am J Epidemiol 1987;125:492–498.

159. Heiberg IL, Hoegh M, Ladelund S, et al. Hepatitis B virus DNA in saliva from children with chronic hepatitis B infection: implications for saliva as a potential mode of horizontal transmission. Pediatr Infect Dis J 2010;29:465–467.
160. Shapiro ED. Lack of transmission of hepatitis B in a day care center. J Pediatr 1987;110:90–92.
161. Canadian Paediatric Society. Health implications of children in child care centres. Part B: Injuries and infections. Paediatr Child Health 2009;14:40–48.
162. Canadian Paediatric Society. A bite in the playroom: managing human bites in child care settings. Paediatr Child Health 2008;13:515–526.
163. Saxén H, Muotiala A, Rostila T, Vuopio-Varkila J. Outbreak of perianal infection in a day-care center. Pediatr Infect Dis J 1997;16:247–249.
164. Riegle L, Cooperstock M. Contagiousness of zoster in a day care setting. Pediatr Infect Dis 1985;4:413.
165. Brunell PA, Taylor-Wiedeman J, Lievens AW. Varicella in day care centers. Rev Infect Dis 1986;8:589–590.
166. Schmitt DL, Johnson DW, Henderson FW. Herpes simplex type 1 infections in group day care. Pediatr Infect Dis J 1991;10:729–734.
167. Centers for Disease Control and Prevention. Prevention of varicella: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2007. MMWR 2007;56(RR-04):1–40.
168. Miron D, Lavi I, Kitov R, Hendler A. Vaccine effectiveness and severity of varicella among previously vaccinated children during outbreaks in day-care centers with low vaccination coverage. Pediatr Infect Dis J 2005;24:233–236.
169. Marin M, Nguyen HQ, Keen J, et al. Importance of catch-up vaccination: experience from a varicella outbreak, Maine, 2002–2003. Pediatrics 2005;115:900–905.
170. Gould PL, Leung J, Scott C, et al. An outbreak of varicella in elementary school children with two-dose varicella vaccine recipients – Arkansas, 2006. Pediatr Infect Dis J 2009;28:678–681.
171. Nguyen MD, Perella D, Watson B, et al. Incremental effectiveness of second dose varicella vaccination for outbreak control at an elementary school in Philadelphia, Pennsylvania, 2006. Pediatr Infect Dis J 2010;29:685–689.
172. Kattan JA, Sosa LE, Bohnwagner HD, Hadler JL. Impact of 2-dose vaccination on varicella epidemiology: Connecticut – 2005–2008. J Infect Dis 2011;203:509–512.
173. Shapiro ED, Vazquez M, Esposito D, et al. Effectiveness of 2 doses of varicella vaccine in children. J Infect Dis 2011;203:312–315.
174. Kuzushima K, Kimura H, Kino Y, et al. Clinical manifestations of primary herpes simplex virus type 1 infection in a closed community. Pediatrics 1991;87:152–158.
175. Cordell RL, Waterman SH, Chang A, et al. Provider-reported illness and absence due to illness among children attending child-care homes and centers in San Diego, Calif. Arch Pediatr Adolesc Med 1999;153:275–280.
176. Cordell RL, MacDonald JK, Solomon SL, et al. Illnesses and absence due to illness among children attending child care facilities in Seattle-King County, Washington. Pediatrics 1997;100:850–855.
177. Frankowski BL, Bocchini JA, Diseases Council on School Health and Committee on Infectious Diseases. Head lice. Pediatrics 2010;126:392–403.
178. Gillespie SM, Cartter ML, Asch S, et al. Occupational risk of human parvovirus B19 infection for school and day-care personnel during an outbreak of erythema infectiosum. JAMA 1990;263:2061–2065.
179. Cartter ML, Farley TA, Rosengren S, et al. Occupational risk factors for infection with parvovirus B19 among pregnant women. J Infect Dis 1991;163:282–285.
180. Gilbert NL, Gyorkos TW, Béliveau C, et al. Seroprevalence of parvovirus B19 infection in daycare educators. Epidemiol Infect 2005;133:299–304.
181. Pickering LK, Reves RR. Occupational risks for child-care providers and teachers. JAMA 1990;263:2096–2097.
182. Centers for Disease Control and Prevention. Risks associated with human parvovirus B19 infection. MMWR 1989;38:81–88, 93–97.
183. Centers for Disease Control and Prevention. Vaccination coverage among children enrolled in Head Start programs and licensed child care centers and entering school – United States and selected reporting areas, 1999–2000 school year. MMWR 2001;50:847–855.
184. Feikin DR, Lezotte DC, Hamman RF, et al. Individual and community risks of measles and pertussis associated with personal exemptions to immunization. JAMA 2000;284:3145–3150.
185. Centers for Disease Control and Prevention and National Association of State Public Health Veterinarians, Inc. (NASPHV). Compendium of measures to prevent disease associated with animals in public settings. MMWR 2009;58(RR-05):1–15.
186. Pickering LK, Marano N, Bocchini JA, et al. Exposure to nontraditional pets at home and to animals in public settings: risks to children. Pediatrics 2008;122:876–886.
187. Crump JA, Sulka AC, Langer AJ, et al. An outbreak of *Escherichia coli* O157:H7 infections among visitors to a dairy farm. N Engl J Med 2002;347:555–560.
188. Centers for Disease Control and Prevention. Outbreaks of *Escherichia coli* O157:H7 associated with petting zoos – North Carolina, Florida, Arizona, 2004 and 2005. MMWR 2005;54:1277–1280.
189. Centers for Disease Control and Prevention. Outbreak of shiga toxin-producing *Escherichia coli* O157 infections associated with a day camp petting zoo – Pinellas County, Florida–May – June 2007. MMWR 2009;58:426–428.
190. Bender JB, Shulman SA, et al. Reports of zoonotic disease outbreaks associated with animal exhibits and availability of recommendations for preventing zoonotic disease transmission from animals to people in such settings. J Am Vet Med Assoc 2004;224:1105–1109.
191. Reves R, Jones J. Antibiotic use and resistance patterns in day care centers. In: Pickering L (ed). Seminars in Pediatric Infectious Diseases. Philadelphia, WB Saunders, 1990, pp 212–221.
192. Thrane N, Olesen C, Md JT, et al. Influence of day care attendance on the use of systemic antibiotics in 0- to 2-year-old children. Pediatrics 2001;107:E76.
193. André M, Hedin K, Håkansson A, et al. More physician consultations and antibiotic prescriptions in families with high concern about infectious illness: adequate response to infection-prone child or self-fulfilling prophecy? Fam Pract 2007;24:302–307.
194. Dunais B, Bruno P, Carsenti-Dellamonica H, et al. Trends in nasopharyngeal carriage of *Streptococcus pneumoniae* among children attending daycare centers in southeastern France from 1999 to 2006. Pediatr Infect Dis J 2008;27:1033–1035.
195. Abut LI, Apan T, Otlu B, et al. The characteristics of nasopharyngeal *Streptococcus pneumoniae* in children attending a daycare unit. New Microbiol 2008;31:357–362.
196. Scheifele DW, Fussell SJ. Ampicillin-resistant *Haemophilus influenzae* colonizing ambulatory children. Am J Dis Child 1981;135:406–409.

197. Reves RR, Fong M, Pickering LK, et al. Risk factors for fecal colonization with trimethoprim-resistant and multiresistant *Escherichia coli* among children in day-care centers in Houston, Texas. Antimicrob Agents Chemother 1990;34:1429–1434.
198. Fornasini M, Reves RR, Murray BE, et al. Trimethoprim-resistant *Escherichia coli* in households of children attending day care centers. J Infect Dis 1992;166:326–330.
199. Public health considerations of infectious diseases in child day care centers. The Child Day Care Infectious Disease Study Group. J Pediatr 1984;105:683–701.
200. Murph JR, Bale JF. The natural history of acquired cytomegalovirus infection among children in group day care. Am J Dis Child 1988;142:843–846.
201. Pass RF, Hutto C, Ricks R, Cloud GA. Increased rate of cytomegalovirus infection among parents of children attending day-care centers. N Engl J Med 1986;314:1414–1418.
202. Clements DA, Moreira SP, Coplan PM, et al. Postlicensure study of varicella vaccine effectiveness in a day-care setting. Pediatr Infect Dis J 1999;18:1047–1050.
203. Peled T, Ashkenazi S, Chodick G, et al. Risk of exposure to hepatitis A virus among day-care workers in Israel: implications for preventive measures. Arch Environ Health 2002;57:332–336.
204. Rosen FS, Ryan MW. The prevalence of colonization with drug-resistant pneumococci among adult workers in children's daycare. Ear Nose Throat J 2007;86:38–44.
205. Reves RR, Pickering LK. Impact of child day care on infectious diseases in adults. Infect Dis Clin North Am 1992;6:239–250.
206. Bourgeois F, Goldman D, Ross-Degnan D. The Economic Burden of Daycare-Associated Illness. Abstract presented at the Pediatric Academic Societies Meeting, Honolulu, HI; 2008.
207. Duff SB, Mafilios MS, Ackerman SJ. Economic evaluation of infection control practices in day care and the home: methodologic challenges and proposed solutions. Pediatr Infect Dis J 2000;19(10 Suppl):S125–S128.
208. Roberts L, Jorm L, Patel M, et al. Effect of infection control measures on the frequency of diarrheal episodes in child care: a randomized, controlled trial. Pediatrics 2000;105(4 Pt 1): 743–746.
209. Gupta RS, Shuman S, Taveras EM, et al. Opportunities for health promotion education in child care. Pediatrics 2005;116:e499–505.
210. Nadel FM, Aronson SS, Giardino AP, et al. Results of an observational study of child care centers in Pennsylvania: varying approaches to health and safety. The Open Pediatric Medicine Journal 2010;4:14–22.
211. Copeland KA, Duggan AK, Shope TR. Knowledge and beliefs about guidelines for exclusion of ill children from child care. Ambul Pediatr 2005;5:365–371.
212. Boyce J, Pittet D. Guideline for hand hygiene in health-care settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. MMWR 2002 51:1–44.
213. Turner RB, Fuls JL, Rodgers ND. Effectiveness of hand sanitizers with and without organic acids for removal of rhinovirus from hands. Antimicrob Agents Chemother 2010;54:1363–1364.
214. Sandora TJ, Taveras EM, Shih MC, et al. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. Pediatrics 2005;116:587–594.
215. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. Pediatrics 2008;121:e1555–e1562.
216. Liu P, Yuen Y, Hsiao HM, et al. Effectiveness of liquid soap and hand sanitizer against Norwalk virus on contaminated hands. Appl Environ Microbiol 2010;76:394–399.
217. Jiang X, Dai X, Goldblatt S, et al. Pathogen transmission in child care settings studied by using a cauliflower virus DNA as a surrogate marker. J Infect Dis 1998;177:881–888.
218. Moreno MA, Furtner F, Rivera FP. New information about group child care and infection rates. Arch Pediatr Adolesc Med 2010;164:1179.