mally than distally (i.e., descending paralysis) (see Table 16–3).

**EPIDEMIOLOGY**

**General Epidemiology**

Polio is a highly contagious, seasonal viral disease (more pronounced in moderate climate countries) caused by three serotypes of poliovirus (types 1, 2, and 3) that infect nearly every person in a given population in the absence of vaccination. Paralytic manifestations are a rare outcome (less than 1%) of poliovirus infections. Important exceptions are island or isolated populations (e.g., Eskimo), which can remain unaffected by the virus for varying periods and after reintroduction can experience outbreaks of poliomyelitis that affect all age groups that were not affected by the previous wave of infection. Poliovirus type 1 appears to be the most neurovirulent of the three serotypes. Most epidemic and endemic cases of poliomyelitis are caused by poliovirus type 1 followed by type 2 and type 3. Peak transmission occurs among infants and young children (tropical areas) and school-aged children (temperate zones). However, outbreaks in isolated communities can give rise to paralytic cases in many older individuals.

Poliomyelitis is transmitted by person-to-person spread through fecal-oral and oral-oral routes or less frequently by a common vehicle (e.g., water, milk). People remain most infectious immediately before and 1 to 2 weeks after onset of paralytic disease, although poliovirus replicates for substantially longer periods and is excreted for 3 to 6 weeks in feces and approximately 2 weeks in saliva. Thus, the period of communicability may be 4 to 8 weeks. Secondary infection rates of susceptible household or institutional contacts, probably mediated by fecal-oral spread, are high, more than 90%. The incubation period between infection and first symptoms (minor illness) is 3 to 6 days and from infection to onset of paralytic disease usually 7 to 21 days, with a range of 3 to 35 days. Most exposures to polioviruses result in inapparent infections. On the basis of serological surveys in the pre-vaccine era and lameness surveys in developing countries, it appears that in the absence of a control program with vaccines, approximately 1 of 200 (0.5%) children will develop paralytic disease after exposure to polioviruses.

Between 1976 and 1995, 48 outbreaks involving approximately 17,000 cases of paralytic poliomyelitis were reported in the literature. These outbreaks involved primarily unvaccinated or inadequately vaccinated subgroups and were caused predominantly by poliovirus type 1 (74%). On the basis of this review, cases in developing countries occurred mostly among children younger than 2 years, whereas cases in industrialized countries tended to occur in older people who had remained susceptible to poliomyelitis. Besides age and being unvaccinated or inadequately vaccinated, several factors have been shown to increase the risk of acquiring paralytic manifestations, including intramuscular injections with diphtheria-tetanus toxoids and pertussis vaccine (DTP) or antibiotics, strenuous exercise, injury such as fractures, and pregnancy. Provocation poliomyelitis describes the enhanced risk of paralytic manifestations that follows injection in the 30 days preceding paralysis onset. Aggravation poliomyelitis describes the elevated risk of paralytic disease that follows strenuous exercise shortly (preceding 24 to 48 hours) before paralysis onset.

Removal of tonsils and adenoids predisposes to bulbar poliomyelitis. Clinical observations on this fact were reported in the early part of the 20th century. Rhesus monkeys, when inoculated with poliovirus in the tonsillopharyngeal region, developed poliomyelitis with greater frequency than when they were inoculated by other routes. Later, von Magnus and Melnick demonstrated that if cynomolgus monkeys were given poliovirus by the oral route, their susceptibility was greatly enhanced in animals that had their tonsils recently removed. Ogra and Karzon studied 40 children before and after removal of tonsils and adenoids. The children ranged from 3 to 11 years of age and had been immunized with live attenuated poliovirus vaccine 6 months to 6 years previously. Before tonsillectomy, IgA poliovirus antibody was present in appreciable titers in the nasopharynx of all children, but no IgM or IgG antibody was detectable. Significantly, however, after tonsillectomy, the preexisting IgA poliovirus antibody level in the nasopharynx sharply declined in all children studied. Mean antibody titers decreased threefold to fourfold. Thus, removal of tonsils may eliminate a valuable source of immunocompetent tissue particularly important in conferring resistance to poliovirus.

Lower socioeconomic status has been shown to be a risk for paralytic poliomyelitis in developing countries, probably because children belonging to the lower socioeconomic group experience more intense exposure to poliovirus (i.e., a higher virus inoculum, which has been shown in experimental studies to be a risk factor for paralytic disease), and these children are also at higher risk for primary vaccine failure after OPV because of more frequent concurrent enterovirus infections.

In a study of twins, concordance with regard to paralytic poliomyelitis was found in 36% of monozygous pairs compared with 6% among dizygous pairs. The authors concluded that the data were consistent with "the theory that susceptibility may be conditioned by the homozygous state of a recessive gene." A histocompatibility leukocyte antigen (HLA) complex study suggested that HLA-encoded genetic factors control resistance to the paralytic form of poliomyelitis. Data on genetic susceptibility to poliomyelitis were reviewed by Wyant, who proposed that multiple linked genes determine whether an infection with poliovirus results in paralytic disease.

The case-fatality rate is variable and depends primarily on the age groups affected. The highest case-fatality rates have been reported from epidemic cases in the early 20th century and among older people but are commonly between 5 and 10%. Even in the 1990s, the case-fatality rate can be as high as occurred in a