Bacterial and Other Infectious Diseases

Anne Schuchat, M.D.,[1] and Jacquelyn A. Polder, B.S.N., M.P.H.[2]

PUBLIC HEALTH IMPORTANCE

Despite important twentieth century advances such as improved sanitation and the availability of several safe and effective vaccines for infants, infectious diseases remain the most common cause of illness in children in the United States. In developing countries, infectious agents are still the predominant cause of mortality during childhood.

Infectious diseases among children range in severity from the self-limited common cold to potentially fatal infections like bacterial meningitis and hemolytic uremic syndrome associated with *Escherichia coli* O157:H7. Otitis media, usually a relatively minor infection, has the potential to permanently impair hearing and thus contribute to learning disability. Other childhood infectious diseases have substantial case-fatality ratios; for example, even when antibiotics are appropriately administered, 12% of meningococcal disease cases result in death.

The public health effects of childhood infections extend beyond the direct disability and death caused by these agents. For example, chronic antibiotic therapy for otitis media can lead to the emergence of antimicrobial resistance and can complicate the management of subsequent infections in the community. Other childhood infections may cause serious outcomes for contacts of the infected children, such as the complications that may occur when pregnant women are exposed to children with rubella or cytomegalovirus infection (*1*,*2*).

From a public health perspective, the most alarming manifestation of childhood infections is the potential for propagation of disease, particularly when transmission leads to widespread community involvement with disease. Infectious disease outbreaks can lead to the closing of schools or child day-care centers and may require emergency vaccination campaigns. The closing of restaurants, recall of contaminated foods, and litigation related to implicated vehicles in common-source outbreaks can have an important effect on a community's economy. Also important are the costs associated with loss of work for parents who must stay home to care for an ill child or one excluded from child day care until he or she is no longer considered contagious. Tourism has even been threatened when travelers fear their children might contract a serious infection in a proposed destination. Good surveillance data can prove invaluable in the management of public concerns.

Recent public health history provides several instances in which illness among children was a sentinel for a problem in the general community. Cases of acquired immunodeficiency syndrome (AIDS) among children with hemophilia were early alerts to the transmissibility of human immunodeficiency virus (HIV) through blood products. A community outbreak of foodborne listeriosis in 1981 was only recognized when >1% of newborns in a Halifax maternity hospital suffered from perinatal listeriosis (*3*). In

---

[1] Division of Bacterial and Mycotic Diseases
National Center for Infectious Diseases
Centers for Disease Control and Prevention
Atlanta, Georgia

[2] Hospital Infections Program
National Center for Infectious Diseases
Centers for Disease Control and Prevention
Atlanta, Georgia

1978, James Todd first described toxic-shock syndrome (TSS) in seven children with severe multisystem disease (*4*). Investigation of epidemic TSS associated with tampon use in 1980 revealed that many TSS cases had occurred in earlier years (*5*).

Many infectious diseases of childhood are preventable through relatively simple measures such as routine vaccination, good hygiene, and careful food preparation. Surveillance for infectious diseases permits us to identify high-risk populations in which improved access to preventive services and health education efforts might produce the greatest benefits. Surveillance for diseases that are not currently preventable provides a baseline to measure the effectiveness of interventions subsequently introduced, as was recently illustrated by surveillance data on *Haemophilus influenzae* type b (Hib) disease in the prevaccine and vaccine eras (*6*) (for additional information about related topics and surveillance activities, see the Vaccination Coverage and Vaccine-Preventable Diseases chapters).

HISTORY OF DATA COLLECTION

Surveillance for infectious diseases has one of the longest histories of all public health issues. The collection of U.S. data on plague, smallpox, and yellow fever began in 1878 (*7*). By 1925, all states were reporting the occurrence of selected diseases to the U.S. Public Health Service. Public health surveillance originally referred to the quarantine of contacts of persons with communicable diseases to observe for early symptoms. Langmuir expanded the term's scope to include the surveillance of populations rather than individuals and used the term to refer to the collection, analysis, and dissemination of data (*7*). Subsequent definitions incorporated certain disease control responsibilities. This action-oriented sense of surveillance for infectious diseases in children is the primary focus of this chapter.

In addition to CDC's well-established systems for the surveillance of nationally notifiable diseases (*8*), several systems for the surveillance of specific infectious diseases are coordinated through programs at CDC. These surveillance systems monitor diseases of particular importance in childhood, such as viral hepatitis, AIDS, Reye's syndrome, TSS, outbreaks of foodborne and waterborne diseases, and vaccine-preventable diseases such as measles, rubella, and influenza. Infections associated with child day care have been included in recently established pilot projects for the surveillance of infectious diseases in child day-care settings. For several years, however, information regarding child care attendance has been a part of routine surveillance for specific infections, such as viral hepatitis, Hib disease, and giardiasis.

CDC SURVEILLANCE ACTIVITIES

Throughout this chapter, various general surveillance activities at CDC are mentioned, but the primary focus is on the Multistate Active Surveillance System to illustrate the use of surveillance data in directing and evaluating public health interventions. The multistate system, initiated in 1986, involves collaborative surveillance for invasive bacterial diseases of substantial importance in childhood. In recent years, diseases under active surveillance have included meningitis and other invasive diseases caused by *H. influenzae*, *Neisseria meningitidis*, group B streptococcus (GBS), *Listeria monocytogenes*, and *Streptococcus pneumoniae*. CDC defines a case as isolation of one of these pathogens from a usually sterile site (e.g., blood or cerebrospinal fluid) in a resident of the active surveillance area.

Standardized case report forms are completed for all cases. For a number of the pathogens, bacterial isolates are sent to CDC laboratories for further tests such as serotyping and molecular subtyping. Information routinely collected on case report forms includes demographic data, the outcome of infection, the clinical syndrome, the anatomic site from which the organism was isolated, and whether the child attended a child-care facility, was hospitalized, and required hospital transfer. For particular pathogens, information is collected on serogroup and antibiotic susceptibility. This population-based surveillance system has been used to detect cases for additional studies, including case-control studies of the efficacy of vaccines against Hib disease. In those studies, surveillance officers help to enroll control subjects and CDC personnel collect additional information on manufacturer, lot numbers, and number of vaccine doses administered. The surveillance system also has identified cases for studies of dietary risk factors for sporadic listeriosis; the results of these studies led to the development of dietary guidelines on how pregnant women can reduce their risk of foodborne listeriosis (*9*).

Surveillance areas have included entire states (e.g., Maryland, Missouri, New Jersey, Oklahoma, and Washington), metropolitan areas (e.g., San Francisco Bay and metropolitan Atlanta areas), several counties within a state (e.g., four counties in Tennessee), or a large geographic unit (e.g., Los Angeles County). Currently, the aggregate population under surveillance includes >20 million people and represents cases detected at 570 hospitals.

Surveillance is indeed **active**; surveillance personnel based at local and state health departments and academic institutions make biweekly calls to contacts in microbiology laboratories serving all acute care hospitals in the surveillance areas. Surveillance officers verify case eligibility (e.g., residence) and enter the data from case report forms into an Epi Info database. Computer diskettes are mailed monthly to CDC, where a surveillance coordinator reviews the data for accuracy and completeness. The central surveillance database is thus updated monthly, with corrections being made at the local levels. The results of additional laboratory tests performed at CDC are sent to the surveillance sites periodically. In addition, some surveillance officers provide local hospitals with periodic summaries of disease reports by coded hospital number. Hospital personnel know the code only for their own hospital and can thus compare disease occurrence in their institution with reported cases in the other area institutions.

Periodically, surveillance officers perform laboratory audits to assess the completeness of active surveillance and to identify additional cases. In some instances, microbiology records for a specified period are reviewed for all hospitals in the surveillance areas. In other audits, records are reviewed in a stratified sample of hospitals (e.g., auditing 100% of institutions with at least 200 beds and 20% of those with fewer beds).

Census data are used for denominators. Surveillance reports use age- and race-specific rates because age is strongly related to risk of disease, and rates of several of these infections are higher for certain racial and ethnic populations than they are for whites. These racial differences are not likely related to race per se but instead to behavioral and socioeconomic factors such as day care attendance, breast-feeding, household crowding, and access to health care.

Surveillance reports vary in frequency, depending on the subject or focus. Recent reports have summarized the entire active surveillance for bacterial meningitis (*10*) as well as several components of the system (*6*,*9*,*11*,*12*). Surveillance personnel meet every 1–2 years, offering additional forums for problem-solving, feedback, and the introduction of new components into the surveillance system. Periodically, the surveillance system has been adapted to exclude a disease for which surveillance is no longer considered feasible or of a high priority. Diseases also may be added to the system, when resources permit, in response to emerging public health needs; for example, in 1992, the active surveillance system was expanded to include the reporting of multidrug-resistant tuberculosis in certain surveillance areas.

A passive surveillance system, the National Bacterial Meningitis Reporting System (NBMRS), has provided information on culture-confirmed cases of bacterial meningitis since 1979. Reporting is less complete and not as timely as surveillance in the active system; however, the NBMRS does allow the evaluation of longitudinal trends, which would not be possible using surveillance systems that were only introduced recently (see the Interpretation Issues section of this chapter).

Another surveillance system that collects information on infectious diseases important in childhood is the National Notifiable Diseases Surveillance System (NNDSS) (*8*). To help state epidemiologists and health department staff establish a database for the surveillance of numerous diseases and to increase the ease and timeliness of reporting, CDC in 1984 introduced the National

Electronic Telecommunications System for Surveillance (NETSS) (*13*). Six states initially used NETSS, and by 1989, all 50 states and 3 U.S. territories were using the system for the weekly reporting to CDC of 44 of the 49 nationally notifiable diseases (*8*). This computer-based telecommunications system encompasses the collection, transmission, and analysis of the data and the publishing of weekly reports on notifiable diseases from all states as well as New York City, the District of Columbia, and U.S. territories. To enter data, states use a variety of computer systems that are programmed to create data files in standard NETSS format for transmission to CDC. Tables of the number of cases reported by state and region appear each week in the *Morbidity and Mortality Weekly Report*. Although some of the reported conditions have little relevance for children, the reporting of conditions such as measles, mumps, pertussis, and rubella in this system underscores the important role that the NNDSS and NETSS can play in the surveillance of childhood infections (further details on surveillance for vaccine-preventable diseases appear in the Vaccine-Preventable Diseases and Vaccination Coverage chapters).

The Public Health Laboratory Information System (PHLIS) is yet another resource for the surveillance of infectious diseases. The system is based in state health department laboratories. Selected results are reported electronically from these laboratories to appropriate programs within CDC. Examples of data transmitted via PHLIS are the results of serotyping *Salmonella* isolates and, more recently, antimicrobial resistance of *Mycobacterium* tuberculosis isolates. The system is flexible, and new modules for reporting additional diseases can be introduced relatively quickly.

GENERAL FINDINGS

CDC's Multistate Active Surveillance System has consistently demonstrated a strong relationship between age and risk for invasive bacterial diseases (*10*). The highest rates of disease caused by *N. meningitidis*, Hib, *S. pneumoniae*, GBS, and *L. monocytogenes* are among children <5 years old. GBS and *L. monocytogenes* primarily affect children during the first month of life, whereas the highest rates of disease caused by the other three pathogens occur after the first few months, presumably once maternally acquired antibodies are no longer circulating.

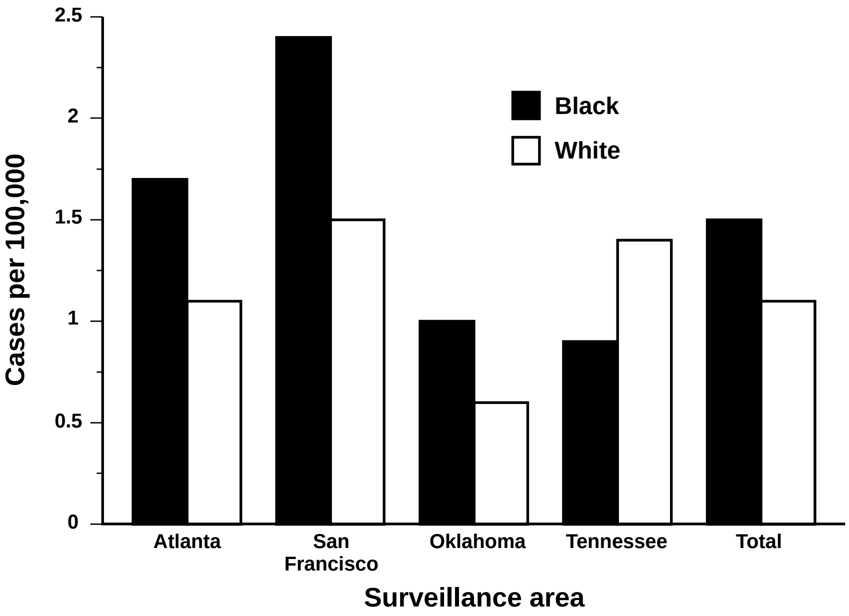
In general, rates of invasive bacterial disease are higher for blacks than for whites. For example, the relative risk of meningococcal disease in 1989–1991 for blacks of all ages was 1.41 (95% confidence interval = 1.10,1.80) the relative risk for persons of other races (Figure 1) (*14*). Active surveillance in 1990 revealed that blacks had twice the rate of neonatal GBS disease as did whites ($p < 0.001$) (*12*). Although blacks have had higher rates of invasive disease caused by Hib than whites, a case-control study nested into a predecessor to the bacterial disease surveillance system in metropolitan Atlanta revealed that after controlling for child day-care attendance and breast-feeding, black race was no longer a risk factor for Hib disease (*15*).

In general, rates of bacterial meningitis have been similar in different surveillance areas, with some regional variations in the incidence of Hib disease (*10*). When New Jersey was stratified into counties with high vs. low prevalence of AIDS, important differences were identified in the rates of invasive pneumococcal disease. Among children of races other than white, those in areas with a high prevalence of AIDS had more than twice the rate of pneumococcal disease as did those living in the low-AIDS areas ($p < 0.05$) (*16*). This finding was consistent with the observation that persons with AIDS have a nearly 300-fold risk of invasive pneumococcal disease (*16*).

Seasonal trends in the occurrence of disease caused by Hib and meningococcus also have been observed. Hib disease peaks in the fall and winter, whereas meningococcal disease peaks in late winter and early spring (*10)*. No consistent seasonal patterns have been detected for disease caused by *L. monocytogenes* or GBS.

Important trends in certain diseases have been evident over the last several years. The most striking example is the decline of childhood Hib disease in the Hib vaccine era. Active surveillance data for 1989–1991 were recently reported along with NBMRS data for 1980–1991, permitting us to compare disease incidence before and after any Hib vaccines were introduced and after the introduction of conjugate vaccines for disease pre-

FIGURE 1. Incidence of meningococcal disease by race — select U.S. areas, 1989–1991



vention (*6*). Because the passive system consistently reported only on cases of meningitis (not all cases of invasive disease) and could not distinguish disease caused by type b from disease caused by other *H. influenzae*, the active surveillance system was important in confirming trends in disease occurrence. In addition, the very high sensitivity of the active system assured that the reduction in disease occurrence was not an artifact of decreased reporting. Active surveillance revealed a 71% decrease in the incidence of Hib disease among children <5 years old, from 37 per 100,000 persons in 1989 to 11 per 100,000 persons in 1991 (Figure 2) (*6*). Increases in doses of Hib vaccine distributed in the United States coincided with declines in Hib disease (*6*).

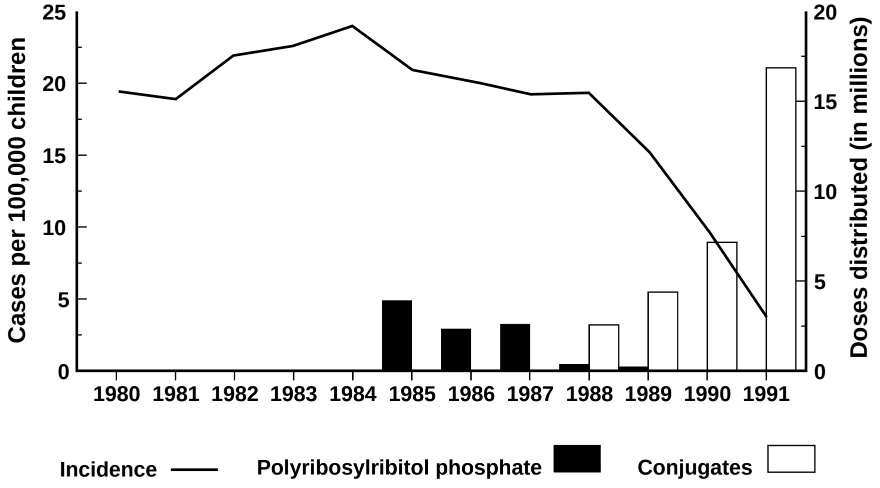
Active surveillance for neonatal GBS disease has revealed both a lower incidence and case-fatality ratio than data from hospital-based series reported in the medical literature (*12*). However, rates of GBS disease among preterm infants are much higher than rates among term deliveries, and many hospital-based series are conducted in tertiary centers or hospitals serving indigent populations, where rates of prematurity and other risk factors may be elevated. The distribution of preterm deliveries in the active surveillance population is similar to national estimates. Therefore, incidence determined through active surveillance is probably a better reflection of disease occurrence nationally than estimates from a few hospitals. The reduced case-fatality ratio for neonatal GBS disease, identified in the active surveillance population (<6% compared with 15%–50% in previous series), probably reflects recent improvements in the management of neonatal sepsis as well as the fact that recent studies reporting higher mortality rates were conducted in relatively high-risk patient populations.

INTERPRETATION ISSUES

The reduced incidence of Hib disease documented by CDC's active surveillance system has raised numerous questions (*6*). Although the striking decrease in disease occurrence coincided with the vaccine era, disease in infants <18 months of age declined dramatically before vaccines were licensed for use in that age-group. Was the decline an artifact of decreased reporting, a reflection of natural variation in disease activity, or a biologically explicable phenomenon?

Laboratory audits confirmed that the active surveillance system was quite sensitive in detecting cases of invasive disease caused by Hib. In 1990,

FIGURE 2. ***Haemophilus influenzae*** **type 6 vaccine doses distributed and *H. influenzae* meningitis cases among children <5 years old — 20 states participating in the National Bacterial Meningitis Reporting System — 1980–1991**



surveillance officers audited 81 hospital laboratories to identify case patients <5 years old who were missed by routine surveillance in 1989. This audit demonstrated that active surveillance had identified 95.6% of all Hib cases among children <5 years old. An artifact of decreased reporting in a system this sensitive could not account for the >70% reduction in disease occurrence. Laboratory audits for all hospitals participating in surveillance throughout 1991 suggested that the sensitivity of active surveillance for Hib disease remained high (*6*).

Although data from the passive NBMRS are available for a longer period than data from the active system, case reports do not distinguish disease caused by Hib from disease caused by other *H. influenzae*. Some investigators have postulated that a vaccine-related decrease in Hib disease might be accompanied by an increase in disease caused by nontypeable and other serotypes of *H. influenzae* (*17*). The very specific case definition used in active surveillance permits an ongoing assessment of the possible emergence of other types of *H. influenzae* disease.

Another strength of the active surveillance system for Hib disease is that the system is quite sensitive for both meningitis and nonmeningitic disease. In previous studies, researchers have suggested that Hib vaccines might have higher efficacy for meningitic disease than other forms of Hib disease (*18*). Because the NBMRS tracks meningitis cases only, stable or increasing rates of nonmeningitic Hib disease during the vaccine era would go undetected. The active surveillance system confirmed that both meningitis and nonmeningitic disease caused by Hib have declined during the conjugate vaccine era.

The best explanation to date for the decline in Hib disease among infants before the vaccine was licensed for use in that age-group is that vaccine use among older children interrupted transmission of the organism to younger children. In support of this hypothesis, a recently published study suggested that conjugate vaccines may decrease pharyngeal carriage of Hib (*19*). The possibility that vaccine recipients are protected from disease directly (through vaccine-induced antibody) and are less likely to transmit the disease (by elimination of nasopharyngeal carriage) suggests that Hib disease could be practically eliminated with adequate vaccine coverage. Continued sensitive surveillance is therefore critical to our efforts to follow trends in disease occurrence and to identify populations needing enhanced vaccination coverage.

Recently, NETSS reporting of disease caused by *H. influenzae* was expanded to collect information about the subject's vaccination history. The sensitivity of the NETSS system for Hib reporting needs to be determined. However, the apparent decline in Hib disease during the vaccine era must be monitored. A resurgence of disease among young children because of inadequate vaccination or emergence of disease in older children or adults because of a waning of immunity could herald the need to revise vaccination efforts. Because NETSS provides national data on the occurrence of Hib disease, maintaining this system will be an important means of monitoring this disease throughout the country.

To appropriately interpret surveillance data for **any** disease, we must be aware of the dynamics of clinical practice. Although the case definition used in CDC's active surveillance system requires the isolation of specific bacteria by culture, advances in biotechnology have led to the development of methods for the rapid detection of bacterial antigen, potentially obviating the perceived need for culture methods. The cost, timeliness, and convenience of such methods may lead clinicians to favor rapid methods over classical culture methods. Surveillance systems will need to adapt to such changes in diagnostic practices to assure that case reporting correlates with disease occurrence. Of even more concern is that the replacement of bacterial isolation methods with antigen-based rapid diagnostic methods could severely threaten our ability to evaluate trends in the antimicrobial resistance of various pathogens—an important goal of many infectious disease surveillance systems.

EXAMPLES OF USING DATA

Health authorities can use accurate estimates of the incidence and characteristics of childhood infectious diseases for a variety of purposes. In this section, we present examples of how surveillance data are being used to 1) compare the cost-effectiveness of various strategies for preventing neonatal GBS disease, and 2) determine the need for alternative vaccination strategies for preventing hepatitis B.

Prenatal Screening for Group B Streptococcus

Substantial controversy has surrounded the issue of prenatal screening for GBS carriage. A randomized clinical trial demonstrated that intrapartum antibiotics prevented neonatal GBS disease when given to pregnant women who were identified as GBS carriers and who developed prolonged rupture of membranes (PROM) or preterm labor (*20*). However, maternal carriage of GBS is relatively common (10%–40%), and neonatal GBS disease occurs in only 1%–2% of infants born to carrier mothers. Clinicians and professional organizations questioned whether screening all women for the bacteria during pregnancy would be cost-effective in identifying a high-risk population for intrapartum antibiotics.

Active surveillance data were incorporated into a cost-effectiveness model regarding strategies for the prevention of neonatal GBS disease. Using current population-based rates of neonatal disease, investigators estimated that prenatal screening and the use of intrapartum antibiotics in GBS carriers with PROM or premature delivery would prevent about 3,300 cases annually in the United States and save approximately $16 million in direct medical costs (*21*).

Despite this demonstration that GBS disease prevention using routine prenatal screening and selective intrapartum antibiotics is cost-effective, the practice has not been widely accepted. The Georgia Department of Human Resources is surveying obstetrical providers in Georgia about their knowledge, attitudes, and practices regarding the prevention of neonatal GBS disease to identify barriers to the use of prevention strategies. This survey may be followed by a targeted educational campaign to improve the implementation of prevention strategies. Because metropolitan Atlanta is an area in the active surveillance system, the state health department can use trends in the incidence of neonatal GBS disease in Atlanta to estimate the effect of educational campaigns on disease occurrence.

Alternative Vaccination Strategies for Hepatitis B

Intensive surveillance for viral hepatitis was conducted in four sentinel U.S. counties during 1981–1988; the findings suggest that the strategy of targeting high-risk groups for hepatitis B immunization did not significantly affect disease incidence and that <1% of hepatitis B cases occurred among persons <15 years old (*22*). However, the rise in cases of hepatitis B despite the introduction of hepatitis B vaccine in 1982 suggest that the vaccination strategy was not working. At least 30% of patients with hepatitis B could not be associated with an identifiable risk factor, indicating they would not be identified for a selective immunization strategy. Another problem with the selective strategy was the difficulty in reaching the **high-risk** population to deliver vaccine before infection could occur. After reviewing the surveillance data and considering the obstacles to selective immunization, policymakers concluded that a policy of universal immunization of infants would be preferable. Although the surveillance data did not suggest that hepatitis B was a disease of childhood, the data led to the introduction of another vaccine for universal use in infancy. Long-term surveillance will be needed to determine how the current policy of universal hepatitis B vaccination of infants affects disease occurrence.

FUTURE ISSUES

The future holds tremendous potential for enhancing surveillance for infectious diseases in children. Efforts to link vaccination registries with databases for disease occurrence are a natural goal of efforts to improve the level of childhood vaccination in this country. Streamlining communication among health departments, health-care providers, and federal agencies can enhance the level of compliance with surveillance efforts. One obvious need is to eliminate unnecessary redundance in reporting. Moreover, future surveillance activities will need to target the major public health issues that threaten the health of children, particularly infectious diseases in child day-care settings and the emergence of new pathogens.

Child Day-Care Settings

By the year 2000, an estimated 80% of women with children aged <6 years will be in the workforce; most of their children will be cared for in settings outside their homes. Studies conducted by CDC and others have shown that children who receive outside-the-home child care have an overall risk of acquiring certain infections that is two to three times the risk among children who are cared for exclusively at home (*23*). The health of children in child day-care settings also will have significant economic consequences. Some investigators have attributed more than $1.8 billion in annual excess costs to these illnesses (*23*). Others have suggested that >60% of employee absenteeism in the United States may be directly related to unmet child care needs (*24*).

Fortunately, child day-care settings provide ideal opportunities for disease surveillance, but such efforts will require close networking among health departments, other health professionals, and the facilities that provide the majority of care to U.S. children. Over the coming years, infectious diseases surveillance in child day-care settings will continue to have three critical functions: 1) the early detection of outbreaks of illness in child care settings, many of which have significant potential for spread to the community (for example, a citywide outbreak of shigellosis in Lexington, Kentucky, was perpetuated through transmission at multiple child day-care centers); 2) the identification of facilities with unusually high incidences of infectious diseases requiring public health intervention; and 3) ongoing data collection to monitor the effectiveness of public health and regulatory interventions.

In the future, CDC will continue to conduct epidemiologic studies to identify risk factors for infectious disease and to develop targeted prevention and intervention strategies. CDC also is developing surveillance methodologies that can serve as models to help public health agencies determine the content and extent of infectious disease problems in child day-care settings. To begin evaluating such surveillance methodologies, CDC has cooperative agreements with several local health departments. Various other research, intervention, and evaluation projects are in progress and are planned for the future.

New Pathogens

The emergence of new pathogens has been a continual threat to children's health (*25*). A recent illustration of this phenomenon was a multistate outbreak of bloody diarrhea and hemolytic uremic syndrome caused by *E. coli* O157:H7, traced to contaminated hamburger patties. During the outbreak investigation in the winter of 1993, investigators promptly conducted multistate surveillance for disease caused by *E. coli* O157:H7 by adapting computer software that was already in place in public health laboratories for the surveillance of other diseases. *E coli* has recently been added to the list of nationally notifiable diseases. The emergence of penicillin-resistant pneumococci in the United States is another important threat to children's health, and multidrug-resistant tuberculosis has introduced critical concerns regarding treatment and prevention of tuberculosis in all age-groups. Effective surveillance to monitor antimicrobial resistance for numerous pathogens is needed. As the identification of an apparently new hantavirus associated with an outbreak of acute respiratory failure among young people in the Southwestern states dramatically illustrated (*26*), emerging infectious diseases continue to challenge the public health system at the local, state, and federal levels.

As we approach the turn of the century, we need to go beyond merely responding to public health emergencies by improving our capacity to anticipate and control their occurrence.

REFERENCES

1. Pass RF, Little EA, Stagno S, Britt WJ, Alford CA. Young children as a probable source of maternal and congenital cytomegalovirus infection. N Engl J Med 1987;316:1366–70.
2. Lindegren ML, Fehrs LJ, Hadler SC, Hinman AR. Update: rubella and congenital rubella syndrome, 1980–1990. Epidemiol Rev 1991;13:341–8.
3. Schlech WF, Lavigne PM, Bortolussi RA, et al. Epidemic listeriosis—evidence for transmission by food. N Engl J Med 1983;308:203–6.
4. Todd J, Fishaut M, Kapral F, Welch T. Toxic-shock syndrome associated with phage-group-I staphylococci. Lancet 1978;2:1116–8.
5. CDC. Toxic-shock syndrome—United States. MMWR 1980;29:229–30.
6. Adams WG, Deaver KA, Cochi SL, et al. Decline of childhood *Haemophilus influenzae* type b (Hib) disease in the Hib vaccine era. JAMA 1993;269:221–6.
7. Langmuir AD. The surveillance of communicable diseases of national importance. N Engl J Med 1963;268:182–92.
8. Chorba TL, Berkelman RL, Safford SK, Gibbs NP, Hull HF. Mandatory reporting of infectious diseases by clinicians. In: *CDC Recommendations and Reports*, June 22, 1990. MMWR 1990;39:(No. RR-9):1–17.
9. Schuchat A, Deaver K, Wenger JD, et al. Role of foods in sporadic listeriosis, I: case-control study of dietary risk factors. JAMA 1992;267:2041–5.
10. Wenger JD, Hightower AW, Facklam RR, Gaventa S, Broome CV. Bacterial meningitis in the United States, 1986: report of a multistate surveillance study. J Infect Dis 1990;162:1316–23.
11. Pinner RW, Gellin BG, Bibb WF, et al. Meningococcal disease in the United States—1986. J Infect Dis 1991;164:368–74.
12. Zangwill KM, Schuchat A, Wenger JD. Group B streptococcal disease in the United States, 1990: report from a multistate active surveillance system. In: *CDC Surveillance Summaries*, November 20, 1992. MMWR 1992;41:(No. SS-6):25–32.
13. CDC. National Electronic Telecommunication System for Surveillance—United States, 1990–1991. MMWR 1991;40:502–3.
14. Jackson LA, Wenger JD. Laboratory-based surveillance for meningococcal disease in selected areas, United States, 1989–1991. In: CDC *Surveillance Summaries*, June 4, 1993. MMWR 1993;42(No. SS-2):21–30.
15. Cochi SL, Fleming DW, Hightower AW, et al. Primary invasive *Haemophilus influenzae* type b disease: a population-based assessment of risk factors. J Pediatr 1986;108:887–96.
16. Schuchat A, Broome CV, Hightower A, Costa SJ, Parkin W. Use of surveillance for invasive pneumococcal disease to estimate the size of the immunosuppressed HIV-infected population. JAMA 1991;265:3275–9.
17. Wenger JD, Pierre R, Deaver K, et al. Invasive *Haemophilus influenzae* disease: a population-based evaluation of the role of capsular polysaccaride serotype. J Infect Dis 1992;165(Suppl.1):S34–5.
18. Wenger JD, Pierre R, Deaver KA, et al. Efficacy of *Haemophilus influenzae* type b polysaccaride-diphtheria toxoid conjugate vaccine in US children aged 18-59 months. Lancet 1991;338:395–8.
19. Takala AK, Eskola J, Leinonen M, et al. Reduction of oropharyngeal carriage of *Haemophilus influenzae* type b (Hib) in children immunized with an Hib conjugate vaccine. J Infect Dis 1991;164:982–6.

20. Boyer KM, Gotoff SP. Prevention of early-onset neonatal group B streptococcal disease with selective intrapartum chemoprophylaxis. N Engl J Med 1986;314:1665–9.

21. Mohle-Boetani J, Schuchat A, Plikaytis BD, Smith D, Broome CV. Comparison of prevention strategies for neonatal group B streptococcal disease: a population-based economic analysis. JAMA 1993;270:1442–8.

22. Alter MJ, Hadler SC, Margolis HS, et al. The changing epidemiology of hepatitis b in the United States: need for alternative vaccination strategies. JAMA 1990;263:1218–22.

23. Thacker SB, Adiss DG, Goodman RA, Holloway BR, Spencer HC. Infectious diseases and injuries in child day care: opportunities for healthier children. JAMA 1992;268:1720–6.

24. NCHS. Disability days: United States, 1980. Hyattsville, Maryland: US Department of Health and Human Services, Public Health Service, 1983. (Vital and health statistics; series 10, no. 143.)

25. Lederberg J, Shope RE, Oaks SC Jr, eds. Emerging infections: microbial threats to health in the United States. Washington, DC: National Academy Press, 1992.

26. CDC Update: outbreak of hantavirus infection—southwestern United States, 1993. MMWR 1993;42:441–3.